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VOLUME I of III

TECHNICAL MEMORANDUM NO. 1
INVESTIGATION RESULTS AND ANALYSIS REPORT

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
H.O.D. LANDFILL
ANTIOCH, ILLINOIS

OCTOBER 1993

PREPARED FOR:
WASTE MANAGEMENT OF ILLINOIS, INC.
WESTCHESTER, ILLINOIS

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PREPARED BY:
WARZYN INC.
ADDISON, ILLINOIS

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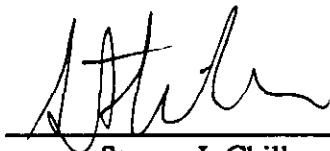
OCTOBER 1993



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INTRODUCTION

1.1 PURPOSE OF REPORT

This report presents the results of Task 3 (Site Investigation) and Task 4 (Site Investigation Analysis) of the Remedial Investigation (RI) for the H.O.D. Landfill site. The purpose of this Technical Memorandum is to document the investigation and analyses performed in accordance with the August 1992 Work Plan (PSER/TS) and to determine whether sufficient data has been collected to proceed with the draft RI. The portion of the RI field program documented in this report was conducted from April to July, 1993.

The work was conducted in accordance with an Administrative Order on Consent (AOC) executed on August 20, 1990 by the U.S. Environmental Protection Agency (U.S. EPA) and Waste Management of Illinois, Inc. (WMII). The purpose of the Remedial Investigation (RI) is to determine the nature and extent of contamination, assess risks to human health and the environment, and provide information for the Feasibility Study.

1.2 BACKGROUND

1.2.1 Site Description

The site consists of a total of 80 acres, 51 acres of which have been landfilled. Although the landfilled area is visually continuous, it consists of two separate landfill areas, identified as the old and the new landfills. The old landfill consists of 24.2 acres situated on the western third of the property. The new landfill consists of 26.8 acres situated immediately east of the old landfill (see Drawing 10010201-F1). The two landfill areas have been legally delineated and a division line established under a special condition of permits (No. 1975-22-DE and No. 75-329) issued by the IEPA, Division of Land Pollution Control.

1.2.2 Location

The site is located within the eastern boundary of the Village of Antioch in Lake County in northeastern Illinois (Township 46 North, Range 10 East, Sections 8 and 9). The site is bordered on the south and west by Sequoit Creek. The Silver Lake residential subdivision is located east of the site and agricultural land, scattered residential areas, and undeveloped land is located to the north. A large wetland area extends south of the site from Sequoit Creek. Silver Lake is approximately 200 feet southeast of the site. A large industrial park area (Sequoit Acres Industrial Park), constructed on former landfill and fill areas, is located west of the site and borders Sequoit Creek. The site location is shown on Figure 1.

In July 1984, Ecology & Environment, Inc. (E&E), a contractor to the U.S. EPA, conducted a site inspection of the H.O.D. Landfill Site. The results of that site inspection, and other available information, were used by E&E to rank the site in April 1985 under the Hazard Ranking System (HRS). The site was scored at 52.02, primarily attributable to an "observed" release of zinc to groundwater and, to a much lesser extent, potential for surface water exposure routes. Based upon the HRS ranking, the site was proposed by the U.S. EPA for inclusion on the National Priorities List (NPL) in Update 4, on September 18, 1985. From November 1986 to September 1989 the U.S. EPA, through its contractors, conducted additional investigations at the site in response to public comments, including those provided by WMII. WMII contended the zinc detected in groundwater at well G103 was related to the deteriorated galvanized casing of the well. In January 1990 a second ranking of the site was performed. The HRS score (34.68) was based in part on the occurrence of contaminants in the surficial sand. A release of contaminants to the deep sand and gravel was not observed. Because the landfill was considered an adequately covered landfill, the surface water score was assigned a value of zero. The air route was scored zero in both evaluations. On February 21, 1990 (55 Fed. Reg. 6154), the H.O.D. Landfill was listed on the NPL.

A number of Potentially Responsible Parties (PRPs) were identified by U.S. EPA. However, only WMII responded to U.S. EPA and agreed to participate in the RI/FS. In early 1990, WMII entered into discussions with the U.S. EPA regarding the conduct of an RI/FS under an AOC that was, following public review and comment, executed on August 20, 1990. In May 1990, Warzyn Inc. (Warzyn) was contracted by WMII to support WMII's RI/FS effort by preparing the Work Plan or Preliminary Site Evaluation Report/Technical Scope (PSER/TS) and to subsequently perform the RI.

1.3 SCOPE

The goal of the RI is to determine the nature of any contaminants present at the site, to determine the extent to which any hazardous constituents have been released into the environment at the site, and to characterize the risk from exposure to any affected media. The data needs for the RI can be grouped into three categories which address each of the following:

- Source Characterization - Characterize the physical and chemical nature of any waste materials and any media in which these wastes are contained.
- Physical and Migration Pathway Characterization - Physically characterize the various media, identify any active contaminant migration mechanisms, and determine the direction and rate of any contaminant movement in any affected media.
- Contaminant Characterization - Determine the location, magnitude, and extent of any contaminants migrating along any pathways of concern.

The scope of this Technical Memorandum is to report the investigative results of the field activities conducted at the site. This report also provides data analysis required to determine if additional activities should be performed for the RI.

1.4 REPORT ORGANIZATION

Section 2 describes the methods used in the field work. Section 3 describes the results of this field work and discusses the laboratory analysis results obtained from the sampling performed during the field activities. Section 4 presents a discussion of contaminant nature and extent. Section 5 describes contaminant fate and transport processes. Section 6 discusses the adequacy of existing data with regards to preparing the RI Report and conducting the Feasibility Study. Section 7 lists the references cited in this Technical Memorandum. Table 1-1 presents a list of acronyms and abbreviations.

This report is presented in three volumes. Volume I consists of the report text, tables, figures, and drawings. Volumes II and III consist of the data appendices, which further document the RI activities.

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REMEDIAL INVESTIGATION ACTIVITIES

The Remedial Investigation (RI) characterizes and delineates suspected contamination at a site, and attempts to quantify the risks to public health and the environment. A description of the activities and rationale for the data collection activities conducted at the H.O.D. Landfill is presented in this section.

2.1 SITE MAPPING AND SURVEYING

An updated topographic base map of the property was prepared by photogrammetric methods to identify physiographic and cultural features. The topographic base map was prepared by Warzyn from an aerial photograph taken on July 21, 1993 by Aero-Metric Engineering, Inc. (Drawing 10010201-F1). The base map was then used for identifying monitoring locations and investigative activities.

In March of 1993, a survey was conducted by Gentile and Associates, Inc. to field stake the proposed-well, monitoring well, leachate well, gas probe, and test pit locations prior to the RI investigation activities. Another survey was completed by Gentile and Associates, Inc. to determine the location and elevation of the existing wells, staff gages, and stand pipes, as well as the new monitoring wells, gas probes, soil borings, and leachate wells installed by Warzyn during the RI investigation activities.

Locations of the investigation points were surveyed on June 28 through July 1, 1993 and are based on the Illinois State Plane Coordinate system. A site grid was also developed for use on the larger sized drawings to assist in referencing site features. The grid shown on Drawing 10010201-F1 shows the state plane coordinate system used during the RI. Elevations were measured relative to mean sea level datum with an accuracy of ± 0.1 ft for ground surface, ± 0.01 ft for top of casing and well pipe, and ± 0.001 ft for horizontal locations.

The location and elevation survey was used in conjunction with other data to develop a site water table map, determine hydraulic gradients, and construct geologic cross-sections.

2.2 SOURCE CHARACTERIZATION

The following activities were performed for the source characterization:

- Landfill Cap Evaluation
- Leachate Collection System Evaluation
- On-Site Surficial Soil/Sediment Sampling
- Leachate Well/Gas Well Installation
- Perimeter Landfill Gas Probe Installation
- Downhole Geophysical Logging
- Leachate Sampling
- Landfill Gas Sampling
- Landfill Soil Borings
- Evaluation of Off-Site Contaminant Sources

2.2.1 Landfill Cap Evaluation

The landfill cap evaluation consists of three main elements: a test pit investigation including geotechnical testing of the in-place cover soils, in-field conductivity testing of the landfill cap, and an estimate of the historical and long-term moisture percolation rate through the cap. Activities conducted to date include the test pit investigation and conductivity testing of the in-place cover soils. Modeling of landfill cap moisture percolation will be performed using the Hydrologic Evaluation of Landfill Performance (HELP) model and results will be included in the RI report. This investigation was performed to evaluate the effectiveness of the existing cap to minimize the infiltration of precipitation.

2.2.1.1 Test Pits

Ten test pit locations were selected based on locations shown in the Work Plan (Drawing 10010201-F2). Locations were selected to include site areas that appeared to be representative of the range of cover soil materials; such as typical, stressed, no vegetation areas, and poorly to well drained areas. Test pits were excavated vertically in the selected areas in May 1993 using a track-mounted excavator. Each test pit was excavated into the cover soils to the depth at which refuse was encountered. Soil profiles and field observations were documented by

a Warzyn soil scientist. Field observations of each test pit included:

- Vegetation characteristics
- Root penetration depths
- Visual soil classification
- Extent of inhomogeneities
- Photographic documentation

In-place density tests, proposed in the work plan to be performed in the field during test pit excavation, were not conducted because alternate techniques could provide the needed data. Unit/weight density tests were performed in the laboratory using Shelby tube soil samples collected from the test pits.

After each test pit was excavated to a depth of at least 60 inches, a detailed cap profile description was made from one of the test pit walls. For safety reasons, in those pits which extended below 60 inches, the remainder of the cap profile below 60 inches was described from outside the test pit, using soil brought up in the excavator bucket.

Individual test pit samples were submitted to Warzyn's soil laboratory for tests which included:

- Grain Size (ASTM D422-63)
- Atterberg limits (ASTM D4318-84)
- Natural moisture content (ASTM D4959-89)
- Clay mineralogy by x-ray diffraction
- Modified Proctor (ASTM D1557-91)
- Laboratory falling head permeability (U.S. Army Corp. of Engineers, Engineering Manual EM1110-2-1906)

Soil samples to be analyzed for grain size, Atterberg limits, moisture content and clay mineralogy, were collected from each layer in the test pit, and placed in appropriate sample jars. Samples sent for analysis were selected, based on field observations, from the most representative zone of the moist, homogeneous clay material layer (the apparent low permeability layer), and various other layers, in each test pit.

Samples for the Modified Proctor tests were obtained with a bucket auger through the bottom casing of the Boutwell unit after completion of the permeability tests (described below), and placed inside double lined garbage bags.

Shelby tube samples for the laboratory falling head permeability and natural density tests were collected from the apparent low permeability layer from each

test pit, utilizing three-inch diameter Shelby tubes pushed vertically into the soil using the excavator bucket, and retrieved vertically with as little sample disturbance as possible. Two Shelby tube samples were randomly selected from both the old and the new landfill.

After completion of each test pit sampling, the test pit was backfilled with the original material, which was placed in the test pit in reverse order of removal and compacted in approximate 1-ft lifts using the excavator bucket.

Test pit logs describing the materials, thicknesses, structure, root growth, vegetative cover, and sample type and depths are included in Appendix A. The soil descriptions are based on the Soil Conservation Service Classification Criteria [U.S. Department of Agriculture (USDA) Handbook No. 436] and soils were visually classified using the Unified Soil Classification System (USCS) and the USDA methods.

2.2.1.2 In-Field Landfill Cap Conductivity Tests - The Boutwell method (ASTM draft method "Standard Test Method for Field Measurement of Hydraulic Conductivity of Porous Materials Using the Two-Stage Borehole Procedure") was followed, less stage 2, for the conductivity tests run on the landfill cap. Ten tests were conducted in June 1993. The conductivity tests were performed within a 20 to 25-ft radius of each test pit, allowing for the use of test pit information in placing and running the conductivity tests.

The Boutwell method measures the rate of flow of water into soil through the bottom of a sealed, cased borehole, utilizing a standpipe in the falling-head procedure. In stage 1, which measures maximum vertical conductivity, the bottom of the borehole is flush with the bottom of the casing. Stage 2, in which the borehole is advanced below the bottom of the casing, and which measures maximum horizontal conductivity, was not used during this investigation. According to the ASTM description of the Boutwell method, stage 2 can be omitted if the purpose of the investigation is to "...verify that the vertical hydraulic conductivity...is less than some specified value, and the apparent vertical conductivity...is less than that value...". The purpose of these tests was to obtain information on the apparent maximum vertical conductivity of the landfill cap. Therefore, stage 2 was not necessary.

The Boutwell apparatus was installed by hand digging a hole down to the low permeability layer based on the corresponding test pit information. When the low permeability layer was reached, the hole was advanced approximately 4 to 8 in. into the layer. The Boutwell apparatus was placed into the hole and the annular space sealed with bentonite chips.

As described in the test method, the casing was filled with water and the system was checked for leaks. The tests began when the stand pipe was full. A stop watch was used for timing, and calibrated standpipe readings were taken at various intervals and recorded. When the drop rate of water in the standpipe became steady over time, the test was completed.

Several of the Boutwell tests were run over a period of two days. Each Boutwell apparatus was pre-wetted for 6 to 12 hours before the test began to help induce the saturated conditions necessary to produce the quasi-steady final results. Boutwell hydraulic conductivity calculations allow for correction for the expansion and contraction effect due to water temperature changes inside the units during the length of the test run, based on a sealed dummy unit. However, the expansion/contraction correction was not applied because of the variability between the dummy unit and each Boutwell unit. Because of shading caused by cloud cover during the course of the apparatus readings, the depth each unit was installed in the cover, the location of each unit relative to shading from the west tree line, and the location of the scale and support struts on the standpipe, condensation on the inside of the standpipes varied considerably between Boutwell units, although it changed slowly throughout the test runs of each individual unit. Sensitivity analysis was used to check the outcome of varying volume changes due to temperature fluctuation, and it was determined that it had a negligible affect on the final calculated hydraulic conductivity rate. However, because of this minor departure from the test method, these test results should not be considered absolute values, but rather relative representations of the permeabilities at each test pit location.

2.2.2 Leachate Collection System Effectiveness

The leachate collection system effectiveness was to be evaluated by pumping from the leachate-collection system and monitoring the change in leachate head in nearby leachate wells. However, the evaluation was not performed as part of the RI because of the results of a similar test run prior to the RI by WMII. During this test, WMII found that leachate could be pumped from the system only until the liquid in storage in the manhole, leachate pipe, and backfill was drained. Then, a recovery period was necessary before more liquid could be pumped.

2.2.3 On-Site Surficial Soil/Sediment Sampling

Five surface soil/sediment samples (SU01 through SU05) were collected on May 14, 1993 from areas which were identified during an inspection of the landfill cap and surrounding area (Figure 10). Surface soil/sediment samples were collected from surface water run-off routes and on-site depositional areas which were observed to have discolored soil and/or water and/or vegetation. Surface soil sample SU01 was collected from an apparent leachate seep located within a deep surface water runoff erosional cut into the landfill cap which emptied into the

seasonally flooded area south of the new landfill area. Sample SU02 was collected in an area on the landfill cap surface which was barren of vegetation, and after periods of rain, was observed to produce gas bubbles through small vesicles, causing black discoloration of the surrounding surface soils. Sample SU03 was collected in the seasonally flooded depositional area south of the new landfill and east of the old landfill from an area which had discolored standing surface water and vegetation. Samples SU04 and SU05 were collected from shallow run-off erosional cuts in the landfill cap which had discolored soils and/or water.

Samples were analyzed for target compound list (TCL) organics, target analyte list (TAL) inorganics, and total organic carbon (TOC). Several geotechnical index parameter tests including grain size analysis, Atterberg limits (to determine the liquid limit and plasticity index), and natural moisture content were performed on the samples. The results of the analysis of the surface soil/sediment samples were used to determine possible routes of contaminant transport.

2.2.4 Leachate Well/Gas Well Installation

During the RI, Environmental and Foundation Drilling, Inc. (E&F) and Warzyn installed 14 leachate wells/gas wells into the landfill refuse during the period of April 6 to May 4, 1993. The purpose of these wells was to collect leachate and landfill gas quality data (Figure 11). Five of the leachate wells were located in the new landfill area (LP5 through LP9) and the remaining nine were installed in the old landfill (LP1 through LP4 and LP10 through LP14). The leachate well borings were drilled using 10 1/4-inch inner diameter (ID) hollow stem augers. The soil borings were sampled with a 2-inch outer diameter (OD) split spoon at five foot intervals from approximately ten feet above the estimated base of the refuse to 2 to 7 feet below the base of the refuse to determine the depth and composition of the material underlying refuse in each soil boring. This information was also used to determine the in-place refuse volume. Soil boring logs for the leachate well borings are located in Appendix B.

The leachate wells were constructed using a washed pea gravel filter pack around 6-inch inner diameter (ID) schedule 80 PVC 0.020-inch slotted screen, with hydrated bentonite filling the annular space above the filter pack around the 6 inch PVC riser pipe. Locking protective casings were installed.

The leachate wells/gas wells were screened from approximately 0 to 5 feet above the base of the landfill to approximately 0.5 to 4.6 feet below the base of the landfill cap. Leachate well construction details are located in Appendix B. This construction method was used so that the leachate wells/gas wells could be used to withdraw both leachate and landfill gas, if necessary, during the Remedial Action (RA) portion of the project.

While drilling the leachate wells an Organic Vapor Meter (OVM) photoionization detector (PID): an Industrial Scientific oxygen, hydrogen sulfide, and combustible gas meter: and a Monitox hydrogen cyanide meter were used to screen drill cuttings and the immediate atmosphere. Soils with PID readings above 5 parts per million (ppm), as well as all refuse material, were transported and placed into an on-site roll-off box. The roll-off box is covered and will remain on-site pending implementation of the source control remedy. Soils with a PID reading less than 5 ppm were disposed of at the location where the borings were performed.

2.2.5 Perimeter Landfill Gas Probe Installation

Three of five proposed perimeter gas probes (GP3, GP4A, and GP5A) were installed on April 15, 21, and 22, 1993, respectively, by E&F and Warzyn (Figure 11, Drawing 10010201-F2). Adjacent property owners would not allow WMIL/Warzyn to install off-site gas probes GP1 and GP2 to the north-northwest of the landfill.

The perimeter gas probes were installed to determine if landfill gas is migrating into or through natural clay soils surrounding the landfill. While drilling gas probes GP4 and GP5, refuse was encountered in the clay fill material. These soil borings were subsequently abandoned and gas probes GP4A and GP5A were drilled and installed in their present locations approximately 30 to 60 feet away from soil borings GP4 and GP5, respectively. The top of the gas probe screens were placed at approximately 5 feet below ground surface. The bottom of the screens varied from 16 to 26 feet below ground surface. Gas probe soil boring logs and construction diagrams are located in Appendix C.

The gas probe soil borings were drilled using 4 1/4-inch ID hollowstem augers and were continuously sampled using a 5-foot long CME sampling tube to the terminus of the borings. The gas probes were constructed using a washed pea gravel filter pack around a 2-inch ID schedule 40 PVC 0.020-inch slotted screen, with hydrated bentonite filling the annular space above the filter pack and around the PVC riser pipe (Appendix C). Locking protective casings were installed.

2.2.6 Downhole Geophysical Logging

Each of the newly-installed leachate wells/gas wells was logged using natural gamma, neutron, gamma-gamma and fluid temperature downhole logging tools by Wooddell Logging Inc. on June 14, 19 and 20, 1993 (Figure 11). The natural gamma logging was used to assess the landfill structure: primarily to determine if intermediate clay cover layers exist within the refuse. The geophysical logs are located in Appendix D.

2.2.7 Leachate Sampling

Five leachate samples were collected by Warzyn from the newly-installed leachate wells/gas wells (LP1, LP6, LP8 and LP11) and the leachate collection manhole East (MHE) on May 12 and 13, 1993 (Figure 11, Drawing 10010201-F2). Sampling was completed using a stainless steel bailer. Sampling equipment was decontaminated in accordance with the Sampling and Analysis Plan.

The leachate wells were sampled for TCL/TAL parameters and the following indicator parameters as listed in the PSER/TS and Table 1-3 of the QAPP.

- Field temperature
- Field pH
- Field specific conductance
- Field Eh
- Field dissolved oxygen
- Chloride
- Sulfate
- Alkalinity
- Total hardness
- Nitrate nitrogen
- Nitrite nitrogen
- Ammonia nitrogen
- Total organic carbon
- Total dissolved solids

The field parameters were measured using a Beckman pH meter; a YSI conductivity, dissolved oxygen, and temperature meter; and an Orion Eh meter. One duplicate sample and one field blank were collected during the leachate sampling. These QA/QC samples were analyzed for the TCL/TAL and indicator parameters as listed in the QAPP. Sampling and analysis was conducted according to the protocols listed in the QAPP and the Sampling Plan. The samples were analyzed by Warzyn and ETC laboratories. Analytical results are located in Appendix P.

2.2.8 Landfill Gas Sampling

Landfill gas samples were collected from the leachate/gas wells (LP1, LP6, LP7, LP8 and LP11) on June 4, 1993 to chemically characterize the landfill gas (Figure 11, Drawing 10010201-F2). The gas samples were collected using a Summa Passivated Sampling Canister after removing one well volume of gas and purging the Tygon tubing sampling line with an SKC pump. A trip blank and filtered duplicate were collected using this same method, as specified in the QAPP. Sampling and analysis was conducted according to the protocols listed in the QAPP and Sampling Plan.

The landfill gas samples were analyzed by ENSECO Laboratories for volatile organic compounds (VOC). Methane, oxygen and carbon dioxide concentrations were measured at the leachate/gas wells, as well as in perimeter gas probes GP3, GP4A and GP5A using a GEM 500 meter. Analytical results are presented in Appendix P.

2.2.9 Landfill Soil Borings

Six landfill soil borings (B1 through B5 and B2A) were drilled and sampled by E&F and Warzyn on April 23 through April 27, 1993 (Drawing 10010201-F2). These soil borings were drilled along the southern perimeter of the old landfill to assess subsurface conditions and evaluate the need for/feasibility of constructing a barrier slurry wall along the perimeter of the landfill to contain leachate. A geologic cross-section of the southern portion of the old landfill was completed using these soil borings to aid in the slurry wall evaluation (Figure B6 and B9). These borings were also used to estimate refuse volume and to aid in determining the extent and thickness of the surficial sand (Drawing 10010201-F4).

The soil borings were drilled with 4 1/4-inch ID hollow stem augers and continuously sampled with a 2-inch OD split spoon according to American Society of Testing and Materials (ASTM) Standards (ASTM:D 1586-84). Soil sample lithology was visually classified in the field by a Warzyn geologist according to the Unified Soil Classification System (USCS). Soil boring logs are located in Appendix E.

One sample from each distinct lithologic unit was collected from each soil boring for geotechnical analysis which included grain size analysis, (sieve plus hydrometer) and Atterberg limits (to determine the liquid limit and plastic index from samples collected from the clay-rich diamict. The diamict is defined as poorly to nonsorted sediment containing a wide range of particle sizes, regardless of sediment genesis). Results of the geotechnical analysis are located in Appendix F.

An OVM PID; an Industrial Scientific oxygen, hydrogen sulfide, and combustible gas meter; and a Monitox hydrogen cyanide meter were used to screen drill cuttings and the immediate atmosphere. Soils with PID readings above 5 parts per million (ppm), as well as all refuse material, were transported and placed into a on-site roll-off box container pending implementation of the source control remedy. Soils with a PID reading less than 5 ppm were disposed of at the location where the borings were performed.

2.2.10 Evaluation of Off-Site Sources

The area west of the site across Sequoit Creek is an industrial park (Sequoit Acres Industrial Park) that contains several companies which are RCRA small quantity hazardous waste generators, a number of registered underground storage tanks, and an old dump area (see Figures 7 and 8). These facilities are potential sources of contamination. A discussion of the Sequoit Acres Industrial Park is contained in Appendix G.

2.3 HYDROGEOLOGIC INVESTIGATION

The RI hydrogeologic investigation was performed to further evaluate subsurface and groundwater flow conditions. This investigation included eight additional borings and the subsequent installation of four additional monitoring wells and four additional wells (Drawing 10010201-F2). These new investigation points were used, along with the existing wells, to further define physical hydrogeologic characteristics (i.e., groundwater flow direction, hydraulic conductivity) and groundwater chemistry.

2.3.1 Evaluation of Existing Wells

The existing groundwater monitoring wells were inspected to confirm their integrity for the RI. This activity was performed by Warzyn Inc. during other RI field activities in order to determine the physical condition of the existing wells. This inspection included an evaluation of the condition of the surface seals and protective casings, and surface drainage from the well. Water levels and total depth measurements were also collected. Some of the wells had permanent Well Wizard sampling pumps installed in them. As such, the pumps were not removed during this inspection to avoid potentially contaminating the pumps and tubing. These wells were assumed to be in adequate condition for the purposes of the RI.

The results of the well evaluation indicated that the existing wells were in adequate condition to meet the data collection requirements of the RI.

2.3.2 Monitoring Well Installation

Four new water table monitoring wells (W4S, W5S, W6S, and W3SA) and four new deep wells (W2D, W3SB, W3D, and W7D) were installed by E & F and Warzyn (Drawing 10010201-F2). These wells were installed in the locations specified in the PSER/TS. However, an adjacent property owner would not allow WMII/Warzyn to install off-site well W1S which was to be located to the southeast of the landfill.

The well borings, with the exception of W3SB and W3D, were drilled with 4 1/4-inch ID hollow stem augers and were continuously sampled with the Central Mine Equipment (CME) 5-foot long sampling tube and/or a 2-inch OD split spoon. Soil sample lithology was visually classified in the field by a Warzyn geologist according to the Unified Soil Classification System (USCS). Soil boring logs are located in Appendix H. Lithologic information from these borings, as well as the existing soil borings and wells, was also used to determine the extent and thickness of the surficial sand and the clay-rich diamict (Drawings 10010201-F4 and F5). Geologic cross-sections along the western and southern boundaries of the landfill were constructed to aid in determining the hydrogeology of the area (Figure 13, 14, and 15).

The wells were constructed using a No. 30 sand pack around a 2-inch ID schedule 40 PVC 0.010-inch slotted screen, with a bentonite slurry mixture and/or hydrated bentonite filling the annular space above the filter pack around the PVC riser pipe. Locking protective casings were installed. The well construction diagrams are located in Appendix H.

Wells W2D and W7D were installed in the deep sand and gravel aquifer on April 17 and 13, 1993 respectively. Wells W2D and W7D were installed to measure potentiometric head, as well as to collect groundwater samples to monitor groundwater quality between the landfill and the private water supply wells located to the east of the Site (Figure 3, Appendix M). Both wells were constructed with a five foot screen located approximately 5 feet below the base of the clay-rich diamict. Soil samples were collected from each of the lithologically distinct surface deposits, clay-rich diamict, and the deep sand and gravel aquifer zones of each boring. These samples were analyzed for grain size (sieve plus hydrometer), and samples collected from the diamict were also tested for Atterberg limits. A Shelby tube was also collected from the clay-rich diamict at each of these borings. The Shelby tube sample collected from soil boring W2D was analyzed for rigid wall hydraulic conductivity, total organic carbon, and porosity.

Wells W3SA, W3SB, and W3D were installed on April 6, 7, and May 25, 1993, respectively, in the wetland area south of the old landfill, in an area where previous borings suggested the clay-rich diamict was thinnest. Wells W3SA and W3SB were screened in the surficial sand, while well W3D was installed through the clay-rich diamict and screened in the deep sand and gravel aquifer. This nest of wells was installed to assess the hydrogeologic continuity of the clay-rich diamict in this area and to evaluate the groundwater quality in the surficial sand and the deep sand and gravel aquifer.

Since the wetland is a semi-permanently flooded area, the water table is near or above the wetland surface. Therefore, the top of the well screen for well W3SA was placed below the water table surface. The intermediate well W3SB was screened at the base of the surficial sand. The deep well W3D was screened in the deep sand and gravel aquifer.

Well W3SB was also drilled with hollow stem augers, but was continuously split spoon sampled starting from the completion depth of W3SA. Well W3D was installed using rotary wash drilling methods. The upper approximately 35 feet was drilled using 8-inch diameter tri-cone bit in order to install and cement grout a permanent 6-inch ID schedule 40 PVC casing in place approximately 5 feet into the clay-rich diamict (located approximately 30 feet below the ground surface). The casing was installed to minimize the potential for cross contamination of the

deep sand and gravel aquifer and surficial sand during drilling operations. The rest of the boring was drilled using a 6-inch diameter tri-cone bit and was continuously split spoon sampled (with the exception of the 56 to 60 foot sampling interval) starting from the completion depth of W3SB.

One soil sample from the surficial sand was collected from well boring W3SB for grain size analysis, and one clay-rich diamict sample was collected from boring W3D for grain size analysis and Atterberg limits. A Shelby tube sample of the clay-rich diamict was also collected from boring W3D and analyzed for rigid wall hydraulic conductivity, total organic carbon, and porosity to evaluate the potential for fluid movement and attenuation of potential contaminants. Geotechnical analytical results are located in Appendix F.

Monitoring well W4S was installed on the west side of Sequoit Creek on the Quaker Industries property on May 26, 1993 (Drawing 10010201-F2) to confirm the lateral extent of the surficial sand and to evaluate the groundwater flow direction on the west side of Sequoit Creek. Well W4S was screened in the surficial sand and the screened interval intersected the water table.

Water table monitoring wells W5S and W6S were installed on April 21 and 16, 1993, respectively, adjacent to existing shallow U.S. EPA wells US4S and US5S, respectively, since wells US4S and US5S were screened below the water table. The new wells were screened across the water table to monitor potential contaminants at the water table surface. Two soil samples were collected from boring W5S and one from boring W6S for geotechnical analysis.

All of the new wells were properly developed, most of them by removing at least 10 to 12 well volumes of groundwater using a decontaminated stainless steel bailer and cable. Wells W2D, W3D, W3SB and W7D were developed by removing at least the estimated volume of water that was lost into the formation during drilling plus ten well volumes. A Keck pump was used to develop W2D and W7D. Well development data is located in Appendix I.

2.3.3 Downhole Geophysical Logging

The new wells installed into the deep sand and gravel aquifer (W2D, W3D, and W7D), as well as, U.S. EPA wells US4D and US6D, also screened in the deep sand and gravel aquifer, were geophysically logged by Wooddell Logging Inc. on June 3 and 4, 1993. These wells, except for W3D, were logged using natural gamma, neutron, and gamma-gamma (or density) logging methods. Well W3D was logged using only the gamma logging tool due to time constraints in the field. The geophysical logging was performed to further assess the physical and hydrogeologic characteristics of the surficial sand, clay-rich diamict, and deep

sand and gravel as an aid to correlating stratigraphy. The geophysical logs are located in Appendix D.

2.3.4 In-Situ Hydraulic Conductivity Testing

Single well in-situ hydraulic conductivity tests have been performed at the Site during previous investigations. Rising head hydraulic conductivity tests were repeated at wells US3S, US3D, US4S, US4D, US6S, US6D, and US1S. These locations were chosen to re-evaluate hydraulic conductivity of the surficial sand (wells US1S, US3S, US4S, and US6S) and deep sand and gravel (US3D, US4D, and US6D) near the southern boundary of the old landfill (US4S, US4D, US6S, and US6D) and near Village well No. 4 (US3S and US3D). Hydraulic conductivity tests were also performed at new wells (W4S, W5S, and W7D). The hydraulic conductivity tests were conducted by Warzyn during the period of June 2, 3, 4 and 9, 1993. The resultant data will be used in conjunction with existing hydraulic conductivity data to assess groundwater flow rates.

The tests were performed on the deeper wells by using a pressurization apparatus to depress the water level in the well. As the pressure was released, a pressure transducer and automatic data logger were used to record the resultant rise in water level. Water table wells were tested by quickly removing one bailer of groundwater from the well and recording the rise in the water level over time with a pressure transducer and automatic data logger. Hydraulic conductivity tests were analyzed using a PC-based aquifer analysis program (AQTESOLV). Tests performed on the water table wells were analyzed using the Bouwer and Rice method for unconfined aquifers. Tests performed on the deeper wells were analyzed using the Cooper method (confined conditions) and the Bouwer and Rice method (unconfined conditions). The Bouwer and Rice method provided a better curve match and therefore was used to estimate hydraulic conductivity. The results of the hydraulic conductivity testing are summarized in Section 3.7.2 and presented in Appendix J.

2.3.5 Groundwater Level Measurements

A full round of water levels were collected by Warzyn on June 8 and 9, 1993. Western Gulf Coast Laboratories, Inc. subsequently collected a round of groundwater levels during the period of August 18, 19, 20, and September 3, 1993. Water level measurements were obtained using an electronic water level indicator, decontaminated with a phosphate free Liquinox wash and rinsed with distilled water prior to collecting water level data and between wells.

The water levels were used to determine groundwater flow characteristics for the surficial sand and the deep sand and gravel aquifer (Drawing 10010201-F6 and F7). This information was also used to calculate

vertical hydraulic gradients, which were used to assess the hydraulic interconnection between the surficial sand and deep sand and gravel aquifer.

2.4 HYDROLOGIC EVALUATION

A hydrologic evaluation was completed to assess the connection between the groundwater in the surficial sand and the surface water in Sequoit Creek and to evaluate the potential for surface water contamination. The investigation included measuring surface water levels in Sequoit Creek, measuring flow in the creek, and observing the creek banks.

2.4.1 Surface Water Flow Measurements

Sequoit Creek flow measurements were obtained at the four staff gage locations (PSG1 through PSG4) on June 8, 1993 using a Gurley flow meter (Drawing 10010201-F2). Flow measurements were obtained at one foot spacings across the open channel of the creek at staff gage locations PSG1 through PSG3 and at two foot spacings at staff gage location PSG4. Prior to collecting the flow measurements, the creek banks were observed to determine their physical nature and vegetation type. This information was used to assess stream loss and gain and the hydrologic connection of Sequoit Creek to the surficial sand and associated wetland.

2.4.2 Surface Water Level Measurements

Surface water level measurements were obtained at existing staff gauges PSG1, PSG2, PSG3 and PSG4 and in the associated standpipes SC1A-D, SC2A-D, SC3B-D and SC4A-D prior to collecting flow measurement data. However, water level measurements collected from standpipe SC3D and SC4A were not used in the evaluation because broken casings made the measurements unreliable. The water levels were read directly from the staff gages and with a electric water level indicator in the standpipes on June 8 and 9, 1993.

2.5 SOIL/SEDIMENT EVALUATION

A soil/sediment evaluation was conducted to assess the potential for contaminated surface soils and/or sediments. The investigation consisted of an observation of the Site, (including Sequoit Creek), and a hydrologic evaluation of the creek. Refer to Section 2.2.3 of Source Characterization, On-Site Surficial Soil and Sediment Sampling, for details on sampling locations.

A Site observation was performed to assess the potential for soil contamination. Soil sampling locations were identified based on the presence of leachate seeps.

discolored soils and other visual observations. Sediment sampling of Sequoit Creek was determined not to be necessary, during the inspection, as visual observations did not indicate any areas which warranted sampling. Proposed sampling locations were presented to U.S. EPA, for approval, prior to sampling.

2.6 AIR EVALUATION

Existing meteorological data has been ordered to determine regional wind direction, windspeed, temperature, and precipitation and will be included in the RI report. The potential for air contamination has been assessed (see Section 4) based on the landfill gas sampling conducted under Source Characterization, Section 2.2.8.

2.7 HUMAN POPULATION EVALUATION

Information has been collected to identify, enumerate, and characterize human populations which could be exposed if contaminants were released from the Site. For a potentially exposed population, information will be collected on population size and location. As part of the Baseline Risk Assessment (to be submitted to U.S. EPA concurrently with the RI Report) these populations will be linked with the potential contaminants of concern (i.e., those that are mutagenic, teratogenic, etc.) to identify potential risk. Copies of water supply logs within an approximate two mile proximity to the Site are presented in Appendix M.

2.8 ECOLOGICAL EVALUATION

An ecological assessment was conducted on July 21, 1993 as described in the U.S. EPA "Region V Scope of Work for Ecological Assessments" (included in Appendix I) which describes the following eight tasks:

- Task 1 - Characterize Site based on existing data and limited field work
- Task 2 - Prepare preliminary ecological assessment
- Task 3 - Prepared detailed Work Plan for further Site investigation
- Task 4 - Conduct Site investigation
- Task 5 - Revise Work Plan, conduct additional investigation
- Task 6 - Prepare summary of biological and chemical data
- Task 7 - Prepare draft Ecological Assessment Report
- Task 8 - Submit final Ecological Assessment Report

Tasks 1, 2, and 7 have been completed and are presented in a separate Ecological Assessment Preliminary Screening Report.

2.9 POTENTIAL MIGRATION PATHWAY/ CONTAMINANT CHARACTERIZATION

The objective of the potential migration pathway/contaminant characterization is to evaluate the magnitude and extent of contamination. Each potential migration pathway was evaluated including:

- Groundwater, including private residence wells and Village of Antioch water supply wells
- Surface water
- Sediments/soils
- Air (landfill gas)

2.9.1 Groundwater

The following groundwater monitoring wells were sampled during the period of May 10, 11, 12, and 14, 1993 and were analyzed for U.S. EPA TCL/TAL parameters list and water quality indicator parameters list specified in the QAPP.

- | | |
|-------------------|--------------------|
| • US1S and 1D | • US3S, 3I, and 3D |
| • US4S and 4D | • W6S |
| • US6S, 6I and 6D | • W7D |
| • G11S and 11D | • W5S |

Monitoring wells W4S, W3SB, and W3D were sampled on June 1, 1993.

These samples were analyzed to determine the nature and extent of potential contamination of the surficial sand and the deep sand and gravel aquifer.

As part of the sampling procedures, a minimum of three well volumes were removed before samples were collected from each well. The samples were collected, preserved and handled in accordance with the QAPP. Proper chain of custody procedures; quality control sampling; and sample labeling were also performed according to the QAPP. Temperature, pH, specific conductance, Redox, and dissolved oxygen were measured in the field (Appendix K). Analytical results are discussed in Section 4, Nature and Extent of Contamination.

Arrangements were made by WMII and Warzyn to have selected Village of Antioch water supply wells and private residence wells sampled. Four of the five private residence well owners allowed samples to be collected from their wells (Figure 3):

- Private wells PW2, PW3, and PW5 were sampled on June 29, 1993. Private well PW1 was sampled on July 1, 1993. Private well PW4 was not sampled because the property owner would not allow access. Village of Antioch water supply wells VW3 and VW5 were also sampled on June 29, 1993 (Figure 2). Samples were analyzed for the TCL/TAL parameters list. The samples were collected, preserved and handled according to the QAPP. Village Well No. 4 was not sampled by Warzyn during the RI due to several reasons. The PSER/TS stated that Village No. 4 would not be sampled since it was to be decommissioned. In addition, a significant volume of oil (more than 100 gallons) was present in the well when it was video logged. The oil present in the well may have biased the results of any sampling activity. However, analytical data collected by the Village was compiled and is discussed in Section 4.

Three of the private residence wells (PW1, PW2 and PW5) were sampled from an outside faucet, while one private well (PW3) was sampled from an inside kitchen faucet. Once the water was determined not to be filtered or softened at the sampling point, the faucet was opened to purge water until the well pump was automatically activated. The water was then allowed to run for at least 15 minutes at which point the attached hose (PW1, PW2, and PW5 only) was removed and the samples were collected. Field measurements of pH, specific conductivity, and

temperature are presented in Appendix K. The results of the private well sampling are located in Section 5.

2.9.3 Surface Water Sampling

Surface water samples were collected on May 14, 1993 at three locations along Sequoit Creek: upstream at sampling location S101, near the bend in the creek at sampling location S201, and at the northwest corner of the Site, at sampling location S301. The collected surface water samples were analyzed for the TCL/TAL parameters list.

The sampling was completed using a decontaminated stainless steel sampling pail. Samples were collected, preserved and handled according to the QAPP.

2.9.4 Sediment and Soil Sampling

Sections 2.2.3 and 2.5 describe the surface soil/sediment sampling locations and methods. These samples were collected and analyzed to characterize the surface soils/sediments and to determine potential contaminant migration pathways.

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SITE PHYSICAL CHARACTERISTICS

3.1 LANDFILL CHARACTERISTICS

The landfill characteristics evaluation consisted of a landfill cap observation and evaluation; a determination of the landfill structure/refuse characteristics; and, a analysis of landfill gas composition and potential migration.

3.1.1 Landfill Cap Physical Observations and Cap Evaluation

Total landfill cover thickness ranged from 49 inches to 87 inches. The apparent low permeability layers (homogeneous and undisturbed with no structure and no root penetration) ranged from 6 to 14 inches thick on the old portion of the landfill, and from 25 to 63 inches thick on the new portion of the landfill. Remnants of the former landfill cap were observed in the lower profile of the old portion of the landfill, beneath the apparent low permeability layer. Some of the remnants appeared to have been scraped off the former upper profile (although roots were still evident) prior to placement of the new cap, while others had relatively intact, undisturbed, profiles. Refuse was generally encountered below the low permeability layer on the new landfill. No fissures or deformities were observed in any of the apparent low permeability layers. Appendix A contains the test pit logs.

The clay content of the cap consists primarily of Illite, with small amounts of scattered iron-chlorite and smectite, based on X-ray Diffraction Analysis performed on samples from the test pits (Appendix N). Illite is a 2:1 layer silicate that is a non expanding clay; therefore, it has a very low shrink/swell capacity. Iron-chlorite and smectite are also 2:1 layer silicates; however, iron-chlorite is a partially expanding clay, and smectite is an expanding clay, so their shrink/swell capacity is higher than that of illite.

Grain size analysis and Atterberg limits tests (Appendix N) identified the apparent low permeability layer materials as lean clay (CL) with trace to some sand and

trace gravel. Natural density tests (Appendix N and Table 3-1) resulted in densities ranging from 105.7 to 128.3 lbs/cu ft. When compared to the maximum density calculated from the Modified Proctor tests (Appendix N and Table 3-1) this results in a level of compaction ranging between 87 to 92%. Natural moisture content (Appendix N and Table 3-1) ranged between 13.7% and 33.6%, with all but test pit TP9 falling below 24%. However, natural moisture content measured from the Shelby tube sample collected from test pit TP9 was 14.5%.

Vertical hydraulic conductivity of the landfill cap was estimated by Boutwell testing. Calculated conductivities ranged from 1×10^{-5} to 4×10^{-8} cm/sec. Typical conductivities were in the 10^{-8} cm/sec range. Results are contained in Table 3-2. Tabulations and conductivity plots are contained in Appendix N. Results from the Boutwell test run near test pit TP9 show a conductivity of approximately 1×10^{-5} cm/sec. Based on corresponding test pit data and the test pit TP9 laboratory falling head permeability test, this conductivity does not appear to be consistent with the physical characteristics of the cover material in that location. The test pit data shows soil structure and apparent low permeability layer thickness similar to most of the other test pits on the landfill; therefore, its conductivity should also be similar. The laboratory falling head permeability test confirms this by resulting in a similar conductivity as the other three laboratory falling head permeabilities.

Results from the Boutwell test run near test pit TP8 show a conductivity of 8×10^{-6} cm/sec. This unit was installed above the apparent low permeability layer, instead of in it, because of the depth of the apparent low permeability layer below the surface. Based on the test pit apparent vertical conductivity profile, if the Boutwell unit had been installed in the apparent low permeability layer, the apparent vertical conductivity in this area would reflect the permeability of the other test areas.

Results from the Boutwell test run near test pit TP1 show a conductivity of approximately 1×10^{-5} cm/sec. While the test pit data does not support this moderately high permeability, the cap material where the Boutwell test was installed, does. Two attempts were made to find the apparent low permeability layer at the same approximate depth as the test pit, and differing profiles were observed in both attempts. It appears that cap material is variable in this immediate area. No apparent low permeability layer was found above 33 inches in the first attempt, and a partially compact layer was identified in the second attempt, although it was a different material than that of the test pit's apparent low permeability layer. The Boutwell unit was installed in the partially compacted layer. The results from this Boutwell location appear to be accurate, based on the type of material it was installed in, and appear to reflect the lack of a truly compacted apparent low permeability layer above 33 inches in the immediate area.

of the test. (The Boutwell unit could not be installed in the original test pit location because the test cannot be conducted within a 12 foot radius of any holes through the cap.)

The Boutwell data was compared to the laboratory falling head permeability tests from samples obtained from the Shelby tubes (see Table 3-1), to confirm that the Boutwell tests and calculations are valid. The laboratory hydraulic conductivity results were consistently one-half magnitude lower (with the exception of test pit TP9) than the Boutwell test results. Therefore, it was concluded that the Boutwell results reflect an accurate average maximum vertical conductivity (with the exception of Boutwells 8 and 9 as previously discussed above) for the cap materials in the test pit areas.

3.1.2 Landfill Structure/Refuse Characteristics

Refuse thickness data was obtained from the newly installed leachate piezometers/gas wells and the landfill soil borings (Table 3-3). Cap thickness was determined from the test pits and the previously existing gas well flare logs, as well as the leachate piezometers and landfill borings. Warzyn boring and test pit logs are located in Appendices E and A, respectively. Gas flare logs are presented in Appendix E.

The refuse thickness in the old landfill ranged from 12 feet in leachate piezometer/gas well LP13 to 36 feet in leachate piezometer/gas well LP4. The refuse thickness in the new landfill ranged from 35.5 feet in leachate piezometer/gas well LP6 to 63.5 feet in leachate piezometer gas well LP8. Based on refuse thickness data, the overall volume of refuse in the landfill was estimated to be approximately 1.3 million cubic yards. Refuse thickness ranged from 3.3 feet in landfill soil boring B1 to 12 feet in boring B5, located along the southern boundary of the old landfill. Geologic cross-section C-C' shows the southern portion of the old landfill structure with respect to the natural geology of the area (Figure 15).

The geophysical logging was also used to assess landfill structure. Primarily, the logs were used to determine if intermediate clay cover layers exist within the refuse. The presence of these clay layers would affect movement of leachate within the landfill and ultimately influence the effectiveness of any leachate collection system. The geophysical logs are presented in Appendix D. The geophysical logs did not suggest that distinct intermediate clay cover layers were present.

The basal material underlying the refuse in the northern portion of the old landfill and underlying the entire new landfill, based on drilling conducted during the RI, consists primarily of gray silty clay. However, refuse in the southern area of the

old landfill was underlain by peat and/or sand in leachate piezometers LP12, LP13, and LP14 (Figure 11) and in landfill borings B1 through B5 (Figure 15 and Drawing 10010201-F4). Peat material was detected in leachate piezometer LP11, and probably overlies the associated surficial sand material (Drawing 10010201-F4). The basal material in leachate piezometer LP3 was a clayey silt and sand material. A physical description of each sub-refuse material is located on the borehole logs in Appendix B.

3.1.3 On-Site Landfill Gas Assessment

To perform the on-site landfill gas assessment, data was collected from the leachate piezometer/gas wells (LP1, LP6, LP7, and LP11) and the three perimeter gas probes (GP3, GP4A, and GP5A). A discussion of landfill gas quality (presence of VOCs) is presented in Section 4.6.1.

The field measurements of methane, oxygen and carbon dioxide collected from the leachate piezometers/gas wells and the perimeter gas probes are located in Table 3-4. Consistent levels of methane, carbon dioxide and oxygen were observed in the gas wells located in the new landfill (LP6, LP7 and LP8). Methane concentrations ranged from 65.4% in gas well LP7 to 67.7% in gas well LP6; carbon dioxide concentrations ranged from 31.1% in gas well LP8 to 34.4% in gas well LP7; and, oxygen levels were only 0.1% due to displacement of oxygen by the methane and carbon dioxide. These are typical of levels for these compounds as generated in landfills.

Concentrations of these compounds in gas well LP11 located in the old landfill (72.3% methane, 26.7% carbon dioxide and 0.1% oxygen) were consistent with the samples collected in the new landfill. However, the field measurements at gas well LP1 indicated atmospheric levels of oxygen at 20.5% and carbon dioxide at 0.4%. Methane was not detected in gas well LP1.

Similarly, no landfill gases were detected in the three perimeter landfill gas probes; only atmospheric concentrations of oxygen ranging from 20.8% to 20.9% were detected.

Based on the landfill characteristics and the landfill gas data collected, landfill gas is being produced throughout the new landfill and in some areas of the old landfill. Off-site landfill gas migration does not appear to be an issue based on the results of the perimeter gas probe field measurements and the physiography of the site. Sequoit Creek bounds the old landfill to the south and west and acts as an off-site landfill gas migration boundary. Therefore, the potential for off-site landfill migration along these boundaries is minimal. As such, the perimeter gas probes (GP3, GP4A, and GP5A) were installed north, east, and south of the landfill to assess potential off-site landfill gas migration in these directions.

Based on the results of the perimeter landfill gas probe field measurements, off-site landfill gas migration appears to be minimal in areas where the landfill overlies natural occurring clay soils or man-made clay barriers. This is due to the highly cohesive and impermeable nature of the clay materials underlying the site.

3.2 CLIMATE

The Site is located within a continental climatic belt characterized by frequent variations in temperature, humidity and wind direction. The average daily minimum temperature is 15°F in January and the average daily maximum temperature is 83°F in July. The average annual precipitation is 32.5 inches. The wettest months are April through September (USDA, 1970).

3.3 PHYSIOGRAPHY

The Site is situated in the vicinity of the Wheaton moraine within the Great Lakes section of the Central Lowland Province. The topography of the area is generally characterized by gentle slopes with poorly defined surface drainage patterns, depressions, and wetlands. The maximum relief in Lake County is 340 feet.

The topography in the vicinity of the Site is generally flat. The most prominent topographic feature in the area is the landfill. The maximum elevation of the landfill is approximately 800 feet mean sea level (MSL). The elevation of Sequoit Creek is approximately 762 feet MSL. Maximum ground surface relief at the Site is approximately 40 feet.

3.4 SURFACE HYDROLOGY

Surface drainage around the Site is generally toward the Fox River, located approximately 5 miles to the west. Locally, surface water flows from the Site toward Sequoit Creek. Sequoit Creek originally flowed northwest from Silver Lake to a point that is now the approximate center and northern boundary of the Site, where it then flowed west toward the Village of Antioch. However, Sequoit Creek was rerouted to flow west from Silver Lake along what is currently the southern boundary of the Site sometime between 1964 and 1967 (Figure 1). At the southwestern corner of the landfill, the creek was routed to flow north along the western boundary of the Site. Approximately 250 feet north of the northwestern corner of the Site, the creek flows toward the west approximately 2 miles before discharging into Lake Marie. Lake Marie eventually discharges to the Fox River. Based on aerial photographs and a 1960 USGS topographic map

of the Site area, the eastern portion of the Site was shown as a wetland prior to landfill development.

Currently Sequoit Creek flows along the southern edge of the site through a wetland which is located south of the landfill (Figure 4). The surficial sand unit located at the site (Drawing 10010201-F4) underlies the northern portion of this wetland. As such, Sequoit Creek appears to obtain most of its water from shallow groundwater discharge from the surficial sand and from surface water discharge from the wetland rather than from stream discharge from Silver Lake.

Water levels collected from the staff gages located in Sequoit Creek and the stand pipes located along Sequoit Creek (Drawing 10010201-F6), as well as the information collected during the stream flow measurements, were used to assess the groundwater-surface water hydrologic relationship between the Sequoit Creek and the surficial sand. The water level measurements at staff gages PSG1 through PSG4 located in Sequoit Creek and their associated stand pipes (SC1A and B), (SC2A, B, C, and D), (SC3B, C, and D), and (SC4A, B, C and D), respectively, on June 8, 1993 are summarized in Table 3-5. The Sequoit Creek flow measurement results are located in Table 3-6.

Based on the results of the water elevations of the staff gages and stand pipes, the water table levels surrounding the staff gage locations show that groundwater levels are elevated in the surficial sand with respect to the surface water levels of Sequoit Creek (Table 3-5). This indicates that the groundwater is flowing from the surficial sand into Sequoit Creek (Drawing 10010201-F6).

Based on the groundwater levels observed in the stand pipes with respect to the staff gauges located along Sequoit Creek, groundwater adjacent to and below the creek was observed to have vertically upward and horizontal components of flow discharging primarily into the creek under low hydraulic gradients.

The stream flow measurements collected at the four staff gage locations were used to calculate total discharge rates of surface water flowing in Sequoit Creek (Table 3-6). The results of the stream flow measurements indicated that stream discharge was increasing from no measurable flow located at staff gage PSG1 to approximately 3 cubic feet per second (ft^3/sec) at staff gage PSG2, then to approximately 6 ft^3/sec at staff gage PSG3. Discharge then decreased slightly to approximately 5 ft^3/sec at staff gage PSG4.

Based on field observations of the physiography of Sequoit Creek, as well as the flow information discussed above, shallow groundwater from the surficial sand and surface water from the wetland both discharge into Sequoit Creek. The Sequoit Creek discharge increases along the southern portion of the stream from

staff gage PSG1 to PSG3. Once the creek turns north and flows out of the wetland and the area containing the surficial sand, the Sequoit Creek discharge appears to diminish.

3.5 SURFACE SOILS

The following surface soil types were present at the site prior to site development, and may still be present in undeveloped areas.

- Houghton muck, wet
- Morley silt loam
- Zurich silt loam
- Peotone silty clay loam
- Peotone silty clay loam, wet
- Mundelein silt loam
- Miami silt loam.

The Houghton muck and Peotone silty clay loam are classified by the USDA Soil Conservation Service (SCS) as hydric soils. The Zurich silt loam and Mundelein silt loam are non-hydric soils that may contain hydric inclusions. The distribution of pre-development surface soils is illustrated on Figure 9. A brief description of each soil type follows.

The **Houghton** series consists of deep, level to depressional, very poorly drained organic soil that formed in fibrous plant remains deposited in swampy areas. The Houghton muck generally receives run off from surrounding uplands and is subject to ponding. The water table is at or near the surface most of the year.

The **Morley** series consists of deep, gently sloping to steep, well drained to moderately well drained soils that formed in thin silty deposits in the underlying calcareous glacial till. The Morley silt loam is generally found on tops of morainic ridges.

The **Zurich** series consists of deep, level to moderately steep, well drained to moderately well drained soils that formed in 2 to 3 feet of silty material and the underlying calcareous stratified silt and sand. The Zurich loam is found on outwash plains.

The **Peotone** series consists of deep, level to depressional, very poorly drained soils that formed in thick silt and clay, water deposited materials. These soils are in low areas throughout the county. The Peotone silty clay loam, wet, is subject to ponding from water that runs off surrounding uplands. The water table is at or

near the surface most of the year. The Peotone silty clay loam is also subject to ponding, but is drained artificially.

The **Mundelein** series consists of deep, level to gently sloping, somewhat poorly drained soils that formed in 2 to 3 feet of silty material over calcareous stratified silt and sand. The Mundelein silt loam occurs on outwash plains mainly in the valley of the Des Plaines River.

The **Miami** series consists of deep, gently sloping to strongly sloping, well drained to moderately well drained soils that formed in thin silty deposits and the underlying calcareous glacial till. The Miami silt loam is generally found in morainal areas.

3.6 REGIONAL HYDROGEOLOGIC SETTING

3.6.1 Regional Geology

3.6.1.1 Unconsolidated Deposits - The bedrock surface in Lake County is completely overlain by thick sequences of glacial deposits. These unconsolidated deposits exhibit evidence of multiple episodes of glacial advances and retreats of late Wisconsinan glaciation. The surface topography of the area is characterized by a series of parallel, onlapping moraines and intermorainal valleys. This morainal complex is composed of deposits of the Wadsworth Till Member of the Wedron Formation. Deposition of the Wadsworth Till represents the last retreat of the Joliet Sublobe of the Lake Michigan Lobe (Willman and Frye, 1970). The moraines decrease in age toward the east and are onlapped by lacustrine deposits of the Lake Chicago plain. Figure 6 presents a generalized stratigraphic column, which summarized the glacial geology in the Site vicinity.

Approximately 90 to 325 feet of Woodforian age glacial deposits overlie bedrock in northeastern Illinois. The Wadsworth Till Member of the Wedron Formation is the primary unconsolidated deposit in Lake County and ranges in thickness from 5 to 150 feet. The Wadsworth Till Member is underlain sequentially by the Haeger Till Member and Tiskilwa Till Member. The Tiskilwa Till Member overlies the Racine Dolomite. A regional geologic cross section is presented on Drawing 10010201-F3. The glacial deposits are discussed in order of deposition in the following paragraphs.

A reddish-gray, silty clay till (Tiskilwa Till Members) overlies the Racine Dolomite in the region. This till unit is generally regarded as the lowermost member of the Wedron Formation that is present in the area (Willman, 1971). The unit is interpreted to be basal till probably deposited by lodgement (Johnson, et. al., 1985). The Tiskilwa Till Member consists of a lower unit consisting of a

sandy silt with clay and a massive main unit which consists of approximately equal percentages of sand, silt and clay. No Site borings have penetrated this unit.

In the vicinity of Antioch, the Tiskilwa Till Member is overlain by the Haeger Till Member of the Wedron Formation. The Haeger Till Member was deposited by the Harvard Sublobe of the the Lake Michigan Lobe, is laterally extensive and consists of sand and gravel outwash deposits with some clay rich diamicts present. Outwash and till deposits of the Haeger Till Member outcrop locally along the western edge of Lake County and westward into McHenry County (see Drawing 10010201-F3).

The Wadsworth Till Member overlies the Haeger Till Member. The Wadsworth ice of the Joliet Sublobe advanced westward across Lake County entraining recently deposited lake sediment and Paleozoic shales and limestone, resulting in a clay-rich debris load. The ice advance terminated near the Chain of Lakes lowlands. As the ice retreated the clay-rich load was deposited as the Wadsworth Till. The Wadsworth Till is characterized by gray, fine-grained clay rich diamict, and interbedded, sorted silts, sands and gravels. Diamict is defined as poorly to nonsorted sediment containing a wide range of particle sizes, regardless of sediment genesis. The diamict is laterally extensive and is present near the surface in most of Lake County.

3.6.1.2 Bedrock Geology - Lake County is located along the northeastern flank of a northwest/southeast trending structural high known as the Kankakee Arch. The bedrock surface of northeastern Illinois varies in depth from 90 to 325 feet below the ground surface (Woller and Gibb, 1976). The bedrock surface dips gradually toward the east and exhibits an uneven surface as the result of pre-glacial erosion.

Throughout most of Lake County, the uppermost bedrock unit is the Silurian dolomite of the Niagaran Series. This dolomite unconformably overlies Upper Ordovician, Maquoketa Group shales, and ranges in thickness from 0 to 270 feet. The Maquoketa Group is the uppermost bedrock unit in small isolated areas along the western portion of the county. The Maquoketa Group ranges in thickness from 100 to 240 feet and consists primarily of thick non-water-bearing shales. The Maquoketa Group is underlain by a sequence of Cambrian and Ordovician sandstones and dolomites which, in turn, overlie Precambrian granite rock. Bedrock stratigraphy is summarized in Figure 5.

3.6.2 Regional Hydrogeology

There are three major aquifers in northeastern Illinois:

- Unconsolidated deposits of glacial origin (such as the deep sand and gravel aquifer at Antioch).
- The shallower dolomite aquifer of Silurian age
- The deep Cambrian-Ordovician aquifer

3.6.2.1 Unconsolidated Deposits - Sand and gravel deposits, which occur as confined, semiconfined and unconfined aquifers associated with the unconsolidated glacial deposits are fairly extensive throughout Lake County. The majority of the confined units are located in the western portion of the county. Many residential wells in the Antioch area, and the Village of Antioch's public water supply system, obtain groundwater from glacially derived sand and gravel deposits. The deep sand and gravel aquifer is confined in the area of the site. The deep sand and gravel aquifer (Haeger Till Member) used by the Village of Antioch and nearby private water supply wells, is recharged in the Fox River Valley, located approximately 4 to 5 miles west of the Site. The unit is present near ground surface in the Fox River Valley area and water from precipitation, lakes, and the Fox River can enter the sand and gravel (Drawing 10010201-F3). Groundwater within this unit flows from this recharge area to the east toward Lake Michigan.

Depths of wells in the sand and gravel are generally less than 140 feet. The highest yielding sand and gravel wells (greater than 500 gpm) are generally located in major valley systems. The generalized stratigraphy of the unconsolidated deposits in northern Illinois is shown on Figure 6.

3.6.2.2 Bedrock Hydrogeology - Groundwater producing units in the deep Cambrian-Ordovician aquifer include the Galena-Platteville Dolomite, Glenwood-St. Peter Sandstone, Ironton-Galesville Sandstone, and Mount Simon Sandstone. The Mount Simon is sometimes considered a separate aquifer because it is separated from the overlying Ironton-Galesville Sandstone by the Eau Claire Shale aquiclude. The shallower dolomite aquifer is separated from the deeper aquifers by the Maquoketa Shale. In some locations, the deeper sand and gravel directly overlie the shallower dolomite aquifer and the two units are hydraulically connected. The generalized stratigraphy of rocks in northern Illinois are shown on Figure 5.

Of the bedrock aquifers, the Silurian dolomite is the primary source of groundwater in Lake County. However, the sand and gravel aquifers provide only

slightly less groundwater than the bedrock aquifers (Illinois State Water Survey, 1976). The yield capacity of the Silurian dolomite aquifer varies depending upon interconnection of fractures and aquifer thickness (Woller and Gibb, 1976). The aquifer is recharged by the downward migration of water from the overlying glacial deposits where sand and gravel deposits are in contact with the bedrock surface.

The depth of wells in the deep aquifer averages about 1,300 feet, and many of the wells yield over 700 gpm. Wells in the shallow dolomite are set to an average depth of about 300 feet.

3.7 SITE HYDROGEOLOGIC SETTING

3.7.1 Site Geology

The Site area is underlain by differentiated deposits of sand, gravel, and silty clay. Soil boring and monitoring well locations are shown on Drawing 10010201-F2. Results of grain size analyses, Atterberg limits testing, TOC analyses, and permeability testing conducted on soil samples during the RI are presented on Table 3-7. Results of soil testing conducted prior to the RI are presented on Table 3-8.

The unconsolidated deposits encountered in borings drilled at the Site consist of a depositional sequence of till and outwash deposits associated with the surficial Cahokia alluvium (Holocene) and underlying Wadsworth and Haeger Till Members of the Wedron Formation. The unconsolidated deposits are divided into four distinct depositional units, in order of increasing depth and age:

- Surface soils
- An elongated surficial sand deposit (that includes deposition within the Wadsworth Till Member and post glacial sand) of limited vertical and lateral extent which is present near the southern boundary of the landfill
- A clay-rich diamict (Wadsworth Till Member)
- A deep sand and gravel aquifer (Haeger Till Member).

A conceptual representation of glacial stratigraphy as it relates to Northern Illinois is shown on Figure 6. Each of these four units is discussed individually in the following paragraphs. Geologic cross-sections depicting Warzyn's interpretation of the glacial deposits underlying the site are presented in Figures 13 through 15. Figure 12 shows the locations of the geologic cross-sections.

Surface Soils - Natural surface soils encountered during the RI included 1 to 1.5 feet of reddish to black topsoil formed as weathered surface of the clay diamict in borings W2D and W7D (Appendix H). Five feet of peat and organic rich clay and silts were found overlying the surficial sand in soil borings drilled in the wetland area (W3SA and W6S). The peat and organic rich clays are representative of fine-grained post-fluvial environments such as wetland or overbank deposits. Four feet of fill (disturbed soil) was also observed overlying 4 feet of peat in soil boring W4S and overlying surficial sand materials in soil boring W5S. See Section 3.1.2 for a description of natural surface soils underlying the landfill.

Surficial Sand - The surficial sand is present only along the southern portion of the site and is not used for public or private water supply. It exhibits an elongated east-northeast to west trending geometry (Drawing 10010201-F4). Structurally the surficial sand thickens from its furthest lateral extent toward the center line of the deposit, reaching its thickest point of 54 feet at soil boring LB4A. The surficial sand was not observed in the northern portion of the landfill (Drawing 10010201-F4). Geologic cross-section B-B' (Figure 14) illustrates the extent of the deposit from a north-south perspective. As shown on geologic cross-section C-C' (Figure 15), the surficial sand underlies refuse in the southern portion of the old landfill. Geologic cross-section A-A' (Figure 13) illustrates the vertical extent of the surficial sand along the southern portion of the old and new landfill.

The surficial sand generally consists of light brown to gray, fine to coarse grained sand, with varying amounts of gravel, silt, and clay. The USCS classification of the surficial sand samples collected from the borings drilled during the RI is SM: a silty sand, sand silt mixture (Table 3-7). A total organic carbon content of 11.7% was detected in a sample collected from soil boring W5S (7-9 ft depth).

Clay-Rich Diamict - The clay-rich diamict is a laterally extensive deposit which contains various amounts of sand, gravel, and silt mixed in a matrix of clay, which contains discontinuous layers and lenses. The clay-rich diamict is present beneath most of Lake County and its regional extent is shown on Drawing 10010201-F3. The clay-rich diamict represents deposits of the Wadsworth Till Member and is present beneath the entire site, based on borings drilled at the site.

The horizontal and vertical extent of the clay-rich diamict in the vicinity of the site is shown on Drawing 10010201-F5. Drawing 10010201-F5 differs from the PSER/TS Drawing 60953-F7 because Warzyn did not estimate the thickness of the clay diamict in soil borings which did not completely penetrate the diamict, as did P.E. Lamoreaux and Associates (PELA) when they prepared Drawing 60953-F7. As such, most of the TSC borings which did not penetrate

the clay till (which were used by PELA to estimate the thickness of the clay till) were not used to construct Drawing 10010201-F5.

Based on the soil borings drilled in the vicinity of the site, the surficial sand is separated from the deep sand and gravel aquifer by the clay-rich diamict. The top of the clay diamict is present immediately beneath the surface soils along the northern portion of the site and may be as deep as 54 feet below ground surface (boring LB4A) where it underlies the surficial sand south of the site. Geologic cross section B-B' (Figure 14) illustrates both the area with the thicker clay-rich diamict and the area with the thinner clay rich diamict. Based on a review of boring logs which penetrated the diamict, the diamict is thickest in the areas surrounding the surficial sand deposits beneath the landfill and north, south, and west of the landfill (e.g., 110.5 feet and 88 feet in soil boring PZ1 and US2D, respectively [Drawing 10010201-F5]). The clay-rich diamict generally is thinner where the surficial sand is thickest. As such, the diamict is thinnest (less than approximately 20-25 feet) south of the landfill.

Based on the results of the geotechnical analysis and the soil samples collected during the RI, the clay-rich diamict is typically light to dark gray massive silty to lean clay, with trace to some sand and trace gravel. The samples submitted for geotechnical analysis are USCS classified as inorganic clays of medium to low plasticity, gravelly, sandy, silty, and lean clays (CL) to (CL-ML) (Table 3-7). Discontinuous thin layers and lenses of sand and silt were also encountered in the soil borings penetrating the diamict (borings W3D, W2D, and W7D).

The geotechnical analysis of the shelly tube samples collected from the clay-rich diamict in soil borings W2D and W3D indicated that total organic carbon content ranged from 3.6% in soil sample W2D (29 feet to 31 feet depth) and 1.64% in soil sample W3D (36 feet to 38 feet depth). The estimated total porosity ranged from 38% to 24% in these shelly tube samples collected from W2D and W3D, respectively.

Deep Sand and Gravel - The deep sand and gravel is laterally extensive and is present beneath the entire site. (Drawing 10010201-F3). The full thickness of the deep sand and gravel is not known, but the unit is at least 185 feet thick in the site vicinity (Ecology and Environment, Inc. 1989). Based on the results of the sieve analysis of the samples collected from the deep sand and gravel aquifer, the upper portion of this unit consists of brown to gray fine to coarse sand, with trace to some gravel, trace to little silt, and trace clay. Lower portions of this unit are poorly sorted and contain greater percentages of gravel. The deep sand and gravel represents outwash deposits associated with the Haeger Till Member (Willman, et.al., 1975).

3.7.2 Site Specific Hydrogeology

As discussed in the previous section, three major aquifers underlie the Site. The following discussion focuses on the deposits of glacial or recent origin. Water-bearing glacial or recent deposits consist of the surficial sand, underlying clay-rich diamict aquiclude and deep sand and gravel aquifer.

Groundwater level data was collected by Warzyn on June 8 and 9, 1993 (Table 3-9). A water table map for the surficial sand (Drawing 10010201-F6) and piezometric surface map for the deep sand and gravel (Drawing 10010201-F7) have been prepared to illustrate groundwater flow directions.

Slug tests were performed on monitoring wells during the RI to estimate horizontal hydraulic conductivity. Resultant hydraulic conductivity estimates are presented in Table 3-10. Conductivity test results obtained from the previous investigations are located in Table 3-11. Laboratory constant head permeability tests were performed on samples collected from the clay diamict by Warzyn during the RI and those test results are located in Table 3-7. Laboratory constant head permeability test results obtained during the previous investigations of the site are also presented in Table 3-8.

3.7.2.1 Surficial Sand - Water level elevations from the water table wells and standpipes screened in the surficial sand indicate that the water table is near the surface and that the groundwater in the surficial sand is flowing in an east to west direction under a shallow hydraulic gradient. Groundwater flow in the surficial sand also has, as discussed in Section 3.4, a component of flow discharging into Sequoit Creek (Drawing 10010201-F6), the rate of which is controlled by the hydraulic gradient and the hydraulic conductivity of the surficial sand.

The results of the single well hydraulic conductivity slug tests performed in the surficial sand in wells (W3SB, W4S, W5S, US1S, US3S, US4S, and US6S) indicate that the horizontal hydraulic conductivity of the surficial sand ranges from $2.10\text{E-}02$ to $3.60\text{E-}04$ centimeters per second (cm/s) (Table 3-10). These results indicate that groundwater flow can readily take place in the surficial sand deposits and are typical for these types of soil materials.

Based on the water level elevations obtained from well nest W3SA and W3SB, a very slight downward vertical hydraulic gradient of 0.002 feet per foot was observed from the water table surface to the base of the surficial sand (Table 3-12, Figure 13). This indicates that even though most of the groundwater movement in the surficial sand is horizontally into Sequoit Creek, that there is slight downward groundwater flow.

3.7.2.2 Clay-Rich Diamict - The clay-rich diamict acts as an aquiclude or aquitard, separating the surficial sand from the deep sand and gravel. Groundwater movement within the clay-rich diamict is primarily downward. Groundwater equipotential lines within the diamict are shown on Figures 13, 14, and 15. The rate of groundwater movement within the diamict is controlled by the hydraulic conductivity of the diamict and the hydraulic gradient across the diamict.

The results of the single well hydraulic conductivity slug tests performed in wells screened in the clay diamict (wells US3I, US6D and US7S) during previous investigations at this site are located in Table 3-10. Horizontal hydraulic conductivities calculated using the Hvorselv Method from the slug tests were $7.9\text{E-}06$ cm/s in piezometer US3I and $8.0\text{E-}06$ cm/s in piezometer US6I. Piezometer US7S was screened through a sand layer and the resultant hydraulic conductivity of $5.80\text{E-}03$ cm/s is not indicative of the clay-rich diamict.

Warzyn did not perform slug tests on wells screened in the clay diamict during the RI, rather, laboratory constant head permeability tests were performed on Shelby tube samples collected from the clay diamict. Laboratory constant head permeability results, obtained from diamict samples collected from monitoring well W2D and W3D, indicated that the vertical hydraulic conductivity of the clay-rich diamict is on the order of $1.50\text{E-}08$ cm/s to $1.70\text{E-}08$ cm/s (Table 3-7). The vertical hydraulic conductivity of the clay diamict ranged from $1.0\text{E-}08$ cm/s to $6.9\text{E-}07$ cm/s, based on constant head permeability tests performed on samples collected from soil borings LB2, LB3, LB4A and LB10 during the previous site investigations (Table 3-8). These results indicate that the vertical and horizontal hydraulic conductivities of the clay-rich diamict are low, and as a result, poor hydraulic communication exists between the surficial sand and the deep sand and gravel aquifer.

Poor hydraulic communication between the surficial sand and the deep sand and gravel aquifer is also substantiated based on the piezometric head elevation differences observed between wells screened in each unit. Groundwater elevations obtained from wells screened in the surficial sand ranged from 761.84 feet MSL in wells G102 and W5S to 764.39 feet MSL in well US1S (Table 3-9), while head elevations in the deep sand and gravel aquifer ranged from 728.14 feet MSL in well US3D to 737.02 feet MSL in piezometer PZ2 (Drawing 10010201-F7, Table 3-8). Approximately 30 feet of head elevation difference exists between the surficial sand and the deep sand and gravel aquifer.

Vertical hydraulic gradients were calculated based on the head elevation differences between wells screened in the surficial sand and the clay-rich diamict, between wells screened in the clay-rich diamict and the deep sand and gravel

aquifer, and between wells screened in the surficial sand and the deep sand and gravel aquifer (Table 3-12). The gradients ranged from 0.4 ft/ft in wells US3I, US3D to 2 ft/ft in wells US6S, US6I.

These results coupled with the calculated hydraulic conductivities indicate that the clay-rich diamict impedes groundwater flow between the surficial sand and deep sand and gravel aquifer. As such, groundwater movement is very slow through the clay-rich diamict even in areas where the clay-rich diamict is thinnest. The average linear groundwater velocity through the clay-rich diamict in the area where it appears to be thinnest (approximately 25 feet) near soil borings W3D, LB10, and LB4A, is estimated to be approximately 0.097 feet per year (ft/yr). The groundwater velocity and travel time through the clay-rich diamict in this area were based on the observed thickness of the clay-rich diamict at approximately 25 feet in soil boring LB10; the vertical hydraulic conductivity of $1.76\text{E-}02$ ft/yr; a porosity of 24% measured in the Shelby tube sample collected from soil boring W3D, and an estimated hydraulic vertical gradient of approximately 1.3 ft/ft. The groundwater travel time through the thinnest area of the clay-rich diamict was estimated to be approximately 258 years in this area.

3.7.2.3 Deep Sand and Gravel Aquifer

The deep sand and gravel aquifer is used for public water supply by the Village of Antioch and for private well use by nearby residences located east of the Site. This aquifer occurs beneath the entire site based on soil borings drilled during the previous site investigations and the RI. The thickness of the deep sand and gravel aquifer is not known since site soil borings have not entirely penetrated this unit.

Regionally, the deep sand and gravel aquifer exists under confined and semi-confined conditions. Groundwater recharge to the deep sand and gravel aquifer occurs primarily from the Fox River Valley where the aquifer outcrops (See Section 3.6.2, Drawing 10010201-F3). As groundwater flows toward the east from the recharge area, the aquifer is confined by the clay diamict.

As discussed in the previous section, the clay-rich diamict overlies the deep sand and gravel aquifer over the entire site and, based on the piezometric head elevations obtained during the RI, the deep sand and gravel aquifer exists under confined conditions. Piezometric head elevations ranged from 728.41 feet MSL in well US3D to 737.02 feet MSL in well PZ2 (Table 3-9). The top of the deep sand and gravel aquifer ranges in elevation from 669.17 feet MSL in soil boring LB10 to 702.77 feet MSL in soil boring VA5.

The groundwater flow direction in the deep sand and gravel aquifer is illustrated on Drawing 10010201-F7. Based on the piezometric head elevations collected on June 8 and 9, 1993 (Table 3-9), the groundwater of the deep sand and gravel

aquifer appears to be flowing from northeast to southwest under a low hydraulic gradient (Drawing 10010201-F7). The groundwater flow direction along the western portion of the site appears to be influenced by the pumping of the Village water supply wells located to the west and southwest of the site. Village pumping records for the period June 6 through June 9, 1993 have been requested from the Village and will be included in the RI Report if and when received.

A groundwater divide in the deep sand and gravel aquifer was shown on the piezometric map included in the PSER/TS. The divide was controlled by the relatively higher groundwater elevation in well PZ2, located south of the landfill (Drawing 10010201-F7). Elevated potentiometric head levels were also measured in well PZ2 by Warzyn (737.02 feet MSL) in June of 1993 and by Weston Gulf Coast Laboratories (737.44 feet MSL) in August of 1993 (Table 3-9). As we stated in the PSER/TS, well PZ2 is partially screened in the clay-rich diamict. The top of the deep sand and gravel aquifer is located at a depth of approximately 74 feet at PZ2 and the sand filter pack was placed at a depth of 65 feet to 82.5 feet, approximately 9 feet into the clay diamict and 8.5 feet into the deep sand and gravel aquifer. The top of the screen was placed at 71.6 feet, only 2.4 feet into the deep sand and gravel aquifer. The groundwater elevation observed at well PZ2 appears to reflect the groundwater head in the lower portion of the clay-rich diamict and not the deep sand and gravel aquifer.

The horizontal hydraulic conductivity of the deep sand and gravel aquifer was estimated using single well slug tests on wells W3D, US3D and US6D. Hydraulic conductivities ranged from $1.10\text{E-}03$ cm/s to $3.80\text{E-}04$ cm/s (Table 3-10). The estimated hydraulic conductivities that were calculated from slug tests performed during the previous site investigations were similar, and ranged from $2.1\text{E-}03$ cm/s to $5.24\text{E-}04$ cm/s (Table 3-11). These results indicate that groundwater in the deep sand and gravel aquifer has the ability to transmit groundwater readily enough for municipal and private use.

3.7.2.4 Landfill Hydraulics

Leachate is present within both the old and new landfills. Leachate elevations and leachate heads (column of leachate present in the landfill base) are presented in Table 3-13. The current leachate extraction system consists of a leachate collection pipe installed on both the west side and east side of the barrier wall between the old and new landfills. In addition, leachate is pumped from existing leachate piezometers P1, P2A, P3A, P8, P9, and P10. The following discussion of landfill hydraulics is based on leachate measurements obtained on August 20, 1993 and groundwater measurements obtained on June 8 and 9, 1993.

Leachate elevations in the old landfill range from 764.84 feet msl at leachate piezometer LP14 (leachate head: 6.6 feet) to 773.12 feet msl at leachate

piezometer LP4 (leachate head: 24.2 feet). These leachate elevations are higher than the groundwater elevations at monitoring wells near the perimeter of the old landfill. The water table elevation near the southern boundary of the old landfill is approximately 762 feet msl. At well G11S (northwestern corner of the old landfill) the groundwater elevation is approximately 765 feet msl. The potential exists for leachate to leave the old landfill via the surficial sand to the south and through the clay berm to the west and discharge to Sequoit Creek. The potential for release of leachate from the old landfill to groundwater and/or surface water would be greater along the southern portion of the old landfill where the surficial sand underlies refuse.

Leachate elevations in the new landfill range from 753.95 feet msl at leachate piezometer LP8 (leachate head: 31 feet) to 779.64 feet msl at leachate piezometer LP6 (leachate head: 25 feet). The highest leachate head was measured at leachate piezometer LP9 (45.8 feet). The new landfill base grade (approximately 717 to 723 feet msl) in the northeast corner of the new landfill is lower than the old landfill because it is underlain by the clay-rich diamict and a clay bottom and per installed along the southern perimeter (where the surficial sand was previously).

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NATURE AND EXTENT OF CONTAMINATION

This section provides a summary of the results of analyses performed on samples collected from the H.O.D. Landfill site as part of the RI/FS. Contaminants detected at the site are grouped by their structure and by their chemical properties. These analysis results are discussed in terms of potential contamination sources, and in terms of pathways and matrices which may have been contaminated by those potential sources. The background concentrations of metals in the soils and groundwater at the site area are discussed.

4.1 SUMMARY

Groundwater samples from the site monitoring wells, the Village of Antioch water supply wells, and private residence wells were collected as a part of the RI for the H.O.D. Landfill, as well as samples of the site surface water, surface soils, leachate, and landfill gas samples. The samples were analyzed for organic (volatile, semivolatile, and pesticide/PCBs), inorganic (metals and cyanide), and groundwater quality indicator parameters.

For the groundwater matrices, VOCs were the only organic compounds detected. VOCs were primarily found in samples from monitoring wells screened in the surficial sand, including wells US4S and W5S, which are located at the southeast corner of the old landfill, and wells US6I (screened in the clay-rich diamict) and W6S which are located in the southwest corner of the old landfill. VOCs were also found in samples from monitoring well US3D, which is screened in the deep sand and gravel aquifer. The VOCs detected belong to the structural class of chlorinated alkenes, and include trichloroethene (TCE), 1,2-dichloroethene

(DCE), and vinyl chloride (VC). In addition, carbon disulfide was detected in well G11S, located in the northwest corner of the old landfill.

Organics detected in the private and village wells include VOCs and semivolatiles. Carbon disulfide was detected in Village Well No. VW5. Semivolatile organic compounds (o-cresol and 4-chloroaniline) were detected in village wells VW3 and VW5, and private well PW2. The source of these compounds is not clear (see Sections 4.7.3 and 4.7.4).

Surface water samples do not appear to be significantly impacted by leachate. Organics detected in surface water samples include the ketones 4-methyl-2-pentanone and 2-hexanone, which were found in a sample obtained from the SW03 location. Semivolatile compounds and any pesticides/PCBs were not detected.

Surface soil samples collected from the sideslopes of the landfill indicate the presence of VOCs and the semivolatile compound groups of phthalates and polynuclear aromatic hydrocarbons (PAHs).

4.2 SAMPLING AND ANALYSIS

This section provides a discussion of the results of the sampling and analysis conducted during the period May through July 1993 at the site. Media sampled include groundwater from the Village of Antioch water supply wells, the private wells, and the site monitoring wells; the surface water from Sequoit Creek; leachate from the landfill; surface soils from the landfill cover; and gas samples from the leachate piezometers/landfill gas wells. The samples collected were analyzed and validated, as specified in the RI/FS Quality Assurance Project Plan (QAPjP) dated December, 1992.

The results of these analyses are presented in report format in Appendix P of this document. Also included in this Appendix is a Data Quality Summary, and laboratory and data validation qualifier definitions. In addition, detected chemical constituents discussed in this section are summarized in Tables 4-1 through 4-10 for ease of review.

<u>Table</u>	<u>Title</u>
4-1	Regulatory Limits
4-2	Summary of Background Metals and Indicator Results
4-3	Summary of Landfill Gas Results
4-4	Summary of Volatile Organic Compounds in Groundwater, Surface Water, Surface Soils, and Leachate
4-5	Summary of Historical Monitoring Well VOC Data
4-6	Summary of Semivolatile Organic Compounds in Groundwater, Surface Water, Surface Soils, and Leachate
4-7	Summary of Metals in Groundwater, Surface Water, Surface Soils, and Leachate
4-8	Summary of Groundwater/Leachate Quality Indicator Results
4-9	Summary of Chemical Constituents Detected at Village of Antioch Water Supply Wells and Private Residence Wells
4-10	Summary of Historical Data for VOCs Detected in Village of Antioch Water Supply Well No. 4
5-1	Summary of Physical and Chemical Properties of Compounds Detected at HOD Landfill

4.3 SITE SOURCE AREAS AND POTENTIAL CONTAMINANT PATHWAYS

The source of potential contamination at the site is the refuse in the old and new landfills. Potential pathways include contaminant releases to the groundwater, to surface water, to surface soils, and to air. Contaminants in the refuse may potentially be leached from the refuse by percolating precipitation, then be transported out of the landfill and into the groundwater and then be discharged to surface water (Sequoit Creek). Leachate may also potentially be released through the side slopes of the landfill (via leachate seeps), causing surface soil contamination. Landfill gas emissions can potentially affect air quality.

Source characterization was accomplished through the analysis of leachate and landfill gas samples. The results were then compared to samples collected from

potential pathways, including groundwater samples, surface soil samples, and surface water samples.

Groundwater samples collected at the site are discussed in terms of the geologic formation the well from which the sample was obtained is screened in: the surficial sand (identified with the postscript "S" for shallow), clay diamict (identified with the postscript "I" for intermediate), and the deep sand and gravel aquifer (identified with the postscript "D" for deep). Groundwater monitoring wells which are on-site (within the WMII property boundary) and off-site (outside the WMII property boundary) are delineated for risk assessment evaluation as follows.

Surficial Sand On-Site

- G11S
- US04S
- US06I
- US06S
- W05S
- W06S

Surficial Sand Off-Site

- US01S
- US03I
- US03S
- W03SB
- W04S

**Deep Sand and Gravel
Aquifer On-Site**

- G11D
- US04D
- US06D
- W07D

**Deep Sand and Gravel
Aquifer Off-Site**

- US01D
- US03D
- W03D

Three surface water samples were collected from Sequoit Creek. Five surface soil samples were collected from the sides of the landfill where evidence of suspected landfill related effects were observed.

4.4 CONTAMINANT GROUPINGS

In order to facilitate the discussion of organic contaminants present at the site, the compounds that were detected have been categorized into major groups based on the compound's chemical structure. The following groupings present compounds detected in various media at the site.

4.4.1 Volatile Organic Compounds (VOCs)

4.4.1.1 Chlorinated alkanes - 1,1-dichloroethane, 1,2 -dichloroethane, chloroethane, 1,2-dichloropropane, methylene chloride, and chloromethane were detected in samples from the site. The chlorinated alkanes are common industrial solvents. Methylene chloride is a common laboratory contaminant. These compounds may undergo biodegradation under the anaerobic conditions found in landfills. Biodegradation of these compounds typically involves the loss of a chlorine atom. The following abbreviations are used in the text:

- 1,1-DCA - 1,1-dichloroethane
- 1,2-DCA - 1,2-dichloroethane
- 1,2-DCPA - 1,2-dichloropropane

The other three VOCs detected are not abbreviated.

4.4.1.2 Chlorinated alkenes - Tetrachloroethene, trichloroethene, dichloroethenes, and vinyl chloride were detected in samples from the site. These compounds are common industrial solvents, and represent a potential degradation sequence. 1,2-dichloroethene is reported as separate cis- and trans- isomers for the landfill gas analysis and for Village of Antioch water supply well No. 4, but as a total of the two isomers for all other analyses. For comparison purposes, total 1,2-dichloroethene results are discussed in this section. The following abbreviations are used in the text:

- PCE - tetrachloroethene
- TCE - trichloroethene
- 1,2-DCE - 1,2-dichloroethene (total)
- 1,1-DCE - 1,1-dichloroethene
- VC - vinyl chloride

4.4.1.3 Aromatics - The aromatic compounds benzene, ethylbenzene, xylene, toluene (together referred to as BEXT), chlorobenzene, and the semivolatile organic compound 1,4-dichlorobenzene (1,4-DCB) were detected in samples from the site. The BEXT compounds are partially water soluble and are related to gasoline and other petroleum hydrocarbon products. 1,4-DCB is used as a soil fumigant, in moth balls, and in disinfecting blocks (such as urinal cakes and recreational vehicle sanitary systems). All of these compounds are used as solvents and as reagents for a variety of manufacturing processes.

4.4.1.4 Ketones - Ketone compounds detected at the site include acetone, 2-butanone (also known as methyl ethyl ketone or MEK), 4-methyl-2-pentanone (methyl isobutyl ketone or MIBK), and 2-hexanone. These compounds are common solvents used in paints, cement adhesives, resins, and cleaning fluids.

Acetone and MEK are typically used in analytical laboratories and can be laboratory contaminants.

4.4.2 Semivolatile Organic Compounds (SVOC)

4.4.2.1 Phenols - Phenol, 2-methylphenol (o-cresol), 4-methylphenol (p-cresol), and 2,4-dimethylphenol were detected in samples from the site. Phenols are used in adhesives, epoxies, plastics, and a variety of synthetic fibers and synthetic dyes.

4.4.2.2 Polynuclear Aromatic Hydrocarbons (PAHs) - PAHs detected at the site consist of naphthalene, 2-methylnaphthalene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, benzo(k)fluoranthene, benzo(a,h)anthracene, and benzo(g,h,i)perylene. This group of compounds is associated with and derived from coal, oil, and the incomplete combustion of carbonaceous materials.

4.4.2.3 Phthalates - Diethylphthalate, and bis(2-ethylhexyl)phthalate were detected at the site. These compounds are associated with plastics and plastic making processes. Phthalates can also be lab contaminants.

4.4.2.4 PCBs - The polychlorinated biphenyl (PCB) Aroclor 1016 was detected at the site. Mixtures of PCBs are identified and sold under the trade names of various Aroclor numbers and were formerly used extensively in various industrial applications.

4.5 COMPOUND CONCENTRATION COMPARISONS

In this section, analytical results of compounds detected at the site are compared to regulatory limits for all these compounds, and for metals analysis only were compared to local background concentrations.

4.5.1 Applicable Regulations

Results of the two site groundwater analyses were compared to U.S.EPA Maximum Contaminant Levels (MCLs), and Illinois Groundwater Quality Standards for potable resource groundwaters (Class I) and general resource groundwaters (Class II). Regulatory limits for all organic compounds and inorganic analytes detected at the site are summarized in Table 4-1.

4.5.2 Background Evaluation

Upgradient samples of groundwater from the deep sand and gravel aquifer were collected (wells W7D and US1D). An upstream sample of Sequoit Creek (S101) was also collected. Background samples of soils and surficial sand groundwater

were not collected. Background soil samples were not collected because the areas sampled were presumed to be contaminated. It was not possible to collect true upgradient background groundwater samples from the surficial sand because the surficial sand is of limited horizontal extent and because of the groundwater flow pattern.

However, because metals exist naturally in soils, some source of natural (background) concentrations is required in order to evaluate metals in on-site soils. For an indication of likely background concentration ranges of metals in soils, two sources were obtained. Observed ranges for background concentrations of metals in soils for the eastern United States are presented in Table 4-7 and are from Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States, U.S. Geological Survey Paper 1270, 1984. A second source, also presented in Table 4-7, is from Chemical Equilibria In Soils, by Willard L. Lindsay (John Wiley & Sons, publishers): Table 1.1 "The Content of Various Elements in the Lithosphere and in Soils". It should be understood that these published ranges represent a wide variety of soils derived from a range of different parent materials, and may not represent the site specific background conditions.

Upgradient groundwater quality in the deep sand and gravel aquifer is represented by groundwater samples collected from upgradient wells US1D and W7D. These two wells are located upgradient of the landfill and are therefore outside of the influence of the landfill. However, two sample points are not sufficient to conduct a meaningful statistical evaluation. Therefore, for comparison purposes, groundwater quality background concentrations were estimated using data from the Illinois State Water Survey's Groundwater Quality Database. The database contained results from 98 samples collected in Township 46N, Range 10E, Lake County, Illinois. Analytical results for total metals and dissolved metals, and indicator parameters were used for a statistical evaluation, as summarized in Table 4-2. For site evaluation purposes, a value of 1/2 the detection limit for non-detect analyses has been used in calculating values in the table. The statistical summary includes the number of samples analyzed; the minimum, maximum, and average concentrations detected; and the standard deviation. The background value was calculated as the average plus two times the standard deviation. The appropriate values have been listed on the analytical summary tables for metals, private wells, and indicator parameters.

**Dissolved Metals Present in Groundwater
Based on Regional Database,
Site Background Samples, and Site Samples**

<u>Metal</u>	<u>Regional Database</u>	<u>Wells US1D, W7D</u>	<u>Site Wells</u>
Calcium	X	X	X
Magnesium	X	X	X
Potassium	X	X	X
Sodium	X	X	X
Barium	X	X	X
Manganese		X	X
Arsenic	X		X
Cadmium	X		X
Copper	X		X
Nickel	X		X
Zinc	X		X
Thallium			X

A comparison of the data from background wells US1D and W7D, with the data from the regional database reveals that results for common dissolved metals (calcium, magnesium, potassium, sodium, and barium) are similar. These metals were present on-site at concentrations greater than regional or site background levels. Manganese was not reported in the regional database.

Of the dissolved metals detected in groundwater samples from the site, arsenic, cadmium, copper, nickel, and zinc were reported in the regional database, but were not detected in background wells US1D and W7D. Of these five metals, cadmium and zinc were detected in the on-site deep sand and gravel aquifer samples at concentrations greater than the regional background value. However, concentrations of arsenic, copper, and nickel, would also be considered above background.

Thallium was not detected in samples included in the regional database, or in background wells US1D and W7D. Thallium was detected in one on-site deep sand and gravel groundwater sample.

4.6 SOURCE CHARACTERIZATION

Potential contaminant sources include landfill gas and leachate.

4.6.1 Landfill Gas

Samples of landfill gas were collected from five leachate piezometer/gas well locations, two from the old landfill (LP1 and LP11) and three from the new landfill (LP6, LP7, and LP8), and were analyzed for VOCs. Results are presented in units of parts per billion, volume to volume in the complete reports included in Appendix P. A summary of landfill gas analytical results is presented in Table 4-3. Results in this table have been converted to the mass to volume unit of mg/m^3 , which is used for risk assessment purposes. Refer to Table 4-3 for the conversion calculation.

VOCs detected in the landfill gas include chlorinated alkanes, chlorinated alkenes, aromatics, ketones, and freons. Concentrations were generally higher in samples from the new landfill than samples from the old landfill, as would be expected. Note that the method compound list for VOCs in gas is more extensive than that used for other matrices. However, the additional VOCs (including trimethylbenzene, ethyl toluene, and three different freons) detected in the landfill gas were not found in the aqueous or soil matrices as tentatively identified compounds.

4.6.2 Leachate

Leachate samples were collected from five locations, including leachate piezometers LP1 and LP11 in the old landfill, and LP6, LP8, and the leachate manhole-east (MHE) in the new landfill.

VOCs detected in the leachate include chlorinated alkenes, chlorinated alkanes, ketones, and aromatic compounds. A summary of the leachate analysis results is presented in Table 4-4. Ketones were found at the greatest concentrations, reaching a maximum concentration of 19,000 $\mu\text{g/L}$ for acetone in leachate piezometer LP8. Ketones were found in all leachate samples, as were aromatic compounds. Ketones were also detected in some of the surface soils samples, and in one surface water sample.

Aromatic compounds found in the leachate samples include benzene, ethylbenzene, toluene, and xylenes, at concentrations of up to 740 $\mu\text{g/L}$ for toluene in leachate piezometer LP11. Aromatic compounds were also detected in some of the surface soil samples.

Chlorinated alkanes, including 1,1-DCA, 1,2-DCA, and chloroethane were detected in samples from leachate piezometer LP1 and the leachate manhole

(MHE). Chloroethane was detected at a maximum concentration of 45 ug/L in leachate piezometer LP1. Chlorinated alkanes were not detected in any other medium (i.e., groundwater, surface water, or soils).

Chlorinated alkenes, including PCE, TCE, 1,1-DCE, 1,2-DCE, and VC, were detected in leachate piezometers LP01, LP11, and the manhole MHE. 1,2-DCE was detected in leachate piezometer LP11 at a maximum concentration of 190 ug/L. Compounds from this group were also detected in some of the groundwater samples.

1,4-Dichlorobenzene, which may be included as either a VOC or SVOC depending on the exact analytical method, was detected in leachate piezometers LP6 and LP11, at 5 and 20 ug/L, respectively. 1,4-DCB was also detected in surface soil sample SU1.

SVOCs detected in leachate samples include phenols, phthalates, and PAHs. A summary of SVOC results is presented in Table 4-6. Phenols were the most prevalent, and were detected in concentrations up to 2,200 ug/L (4-methylphenol) in leachate piezometer LP8.

Phthalates detected in the leachate include diethylphthalate and bis(2-ethylhexyl)phthalate at concentrations of 4 to 42 ug/L. Phthalates are considered common laboratory contaminants, and are qualified during data validation, when blanks reveal contamination, or when concentrations are less than 100 ug/L and results are determined to be due to laboratory contamination based on professional judgment. Phthalates are often components of leachate, and therefore the results were not qualified. Phthalates were not detected in the groundwater samples. Phthalates were also detected in some of the surface soil samples.

Naphthalene was the only PAH detected in the leachate, and was found at concentrations of 6 to 34 ug/L. Naphthalene is the simplest PAH, and is used as a solvent for a wide range of industrial and agricultural applications. PAHs were also detected in some of the surface soil samples.

Of the 23 metals analyzed for, 21 were found in the leachate samples (the exceptions were antimony and selenium). Metals results are summarized in Table 4-7. Leachate samples are not filtered for metals analyses; reported metals concentrations represent both dissolved metals and metals adsorbed on suspended particles. While MCLs (or IEPA Class I Criteria) are not applicable to leachate, these limits can be used to identify metals present in the source at significant concentrations. The metals that were detected in the leachate at above the MCLs (or IEPA Class I Criteria) include: aluminum, arsenic, beryllium, cadmium,

chromium, copper, iron, lead, magnesium, manganese, nickel, thallium, and zinc. Of these, aluminum, cadmium, iron, manganese, and thallium were also detected in groundwater samples at above the MCLs (or IEPA Class I Criteria).

Leachate samples were analyzed for indicator parameters, as summarized in Table 4-8. As expected, the leachate had elevated levels of total dissolved solids (TDS), alkalinity, hardness, chloride, ammonia-nitrogen, and total organic carbon (TOC).

4.7 MEDIA CHARACTERIZATION

4.7.1 Surface Soils

Surface soil samples were collected from the landfill sideslope at areas of obvious staining or leachate seepage. As such, the surface soil samples exhibited contamination similar to the leachate.

VOCs detected in the surface soils include aromatics, carbon disulfide, acetone and methylene chloride, as summarized in Table 4-4. Aromatics detected include benzene, ethyl benzene, toluene, and xylenes, at concentrations of 2 to 280 ug/kg. These compounds are usually associated with gasoline and other petroleum products. Carbon disulfide was detected in surface soil sample SU2 at 6 ug/kg. Methylene chloride and acetone were also detected in the samples. It should be noted that acetone and methylene chloride at low concentrations (less than 10 times the quantitation limit) are frequently due to laboratory contamination. Because field blanks are not collected for soil samples, the potential for possible contamination of samples due to transportation and storage cannot be determined.

SVOCs detected in the surface soils include phthalates and PAHs. The compound bis(2-ethylhexyl)phthalate was detected in all the soil samples at concentrations of 160 to 9600 ug/kg. Phthalates are commonly associated with plastics. PAHs were found in surface soils at concentrations of 36 to 1000 ug/kg. With the exception of naphthalene found in the leachate, no PAHs were found in any of the other samples analyzed during the RI. PAHs are commonly associated with the incomplete combustion of petroleum products.

The pesticide 4,4'-DDT was detected at a concentration of 4.3 ug/kg in surface soil sample SU1, which was collected at a leachate seep on the south sideslope of the new landfill. DDT, which has been restricted from use since 1973, is a persistent pesticide that resists biodegradation and is strongly adsorbed to soil. Complete degradation of DDT may take 30 years or longer. This compound may be a relict of past pesticide application to the agricultural soils. No other pesticides were detected in any other samples collected during the RI.

Metals results from the soil samples collected for the RI are presented in Table 4-7. Because background soil samples were not collected, these results are compared to published ranges for metals found in natural soils, as discussed in Section 4.5.2. Metals detected in the soils at concentrations exceeding the published background ranges include cadmium and magnesium. Analytical results for most metals were similar among the five soil samples. Metals detected in all these the soil samples include aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc. Cadmium and thallium were only detected in two soil samples: SU3 and SU5 for cadmium and SU1 and SU5 for thallium. Antimony, cyanide, silver, and selenium were not detected in the soil samples.

4.7.2 Groundwater

Results of groundwater monitoring well analysis are grouped below by formation sampled. In addition, the analytical results from the on-site versus the off-site wells are also discussed. The Village of Antioch municipal well analyses and the private well analyses are discussed separately in Sections 4.7.3 and 4.7.4, respectively.

In addition to the groundwater quality data collected during May and June 1993, historical data for the groundwater monitoring wells from 1987 to 1990 has been incorporated into this discussion. The use of this historical data allows for a better understanding of the fate and transport of the contaminants over time.

A summary of VOC results is presented in Table 4-4. VOC results are also presented on Drawing 10010201-F9. A summary of historical groundwater data is presented in Table 4-5. SVOC results are summarized in Table 4-6. Metals results are summarized in Table 4-7. Groundwater quality indicator parameter results are summarized in Table 4-8.

Groundwater quality is discussed in the following sections. Groundwater monitoring well data is discussed according to whether the wells are on-site or off-site and according to which formation is being monitored (data from the surficial sand and clay-rich diamict wells have been included in the same group and are discussed under surficial sand).

4.7.2.1 On-Site Surficial Sand - The on-site surficial sand monitoring wells sampled during the RI include US4S and W5S in the southwestern corner of the old landfill, US6S and W6S in the southeastern corner of the old landfill, and G11S in the northwestern corner of the old landfill. Well US6I, located adjacent to well US6S and W6S, is screened in the clay-rich diamict. These wells are located within the property boundary, but are outside the limits of refuse.

VOCs detected in groundwater samples from the on-site surficial sand monitoring wells are primarily chlorinated alkenes including TCE, 1,2-DCE, and VC. These compounds were detected near the southwest and southeast corners of the old landfill.

1,2-DCE was detected at 35 ug/L in monitoring well US4S, located at the southwest corner of the old landfill. Historically, the concentration of 1,2-DCE at this location has decreased steadily from a maximum concentration of 76.4 ug/L in 1987 to 41.5 ug/L in 1990.

Vinyl chloride was detected at 19 ug/L in the sample from the new monitoring well W5S, also located in the southwest corner of the old landfill. The presence of VC may be the result of the biodegradation of 1,2-DCE. Historically, VC was not detected in the older, deeper monitoring well US4S (although 1,2-DCE was detected, as discussed above) which is located adjacent to well W5S.

Well W5S is a water table well screened across the water table surface. Well W5S is screened from approximately 5 to 14 feet below ground surface (bgs) and the depth to water at this location is approximately 9 feet bgs. Well US4S is screened at a depth of approximately 17 to 23 feet bgs, which is deeper than Well W5S. This may partially explain the different VOCs and VOC concentrations detected at Wells W5S and US4S.

No VOCs, SVOCs, or pesticides/PCBs were detected at deeper well US4D, screened in the deep sand and gravel aquifer (See Section 4.7.2.3). No wells are screened in the clay-rich diamict at this location (in the southwest corner of the old landfill).

TCE was detected at 2 ug/L in monitoring well US06I, located at the southeast corner of the old landfill. Historically, TCE has been detected in well US6I at concentrations of 5 to 8.7 ug/L.

1,2-DCE was also detected at 2 ug/L in monitoring well W6S. Chlorinated alkenes were not reported in the historical data for US6S, located adjacent to well W6S.

Well W6S can be considered to be a water table well even though it is screened from approximately 6 to 15 feet bgs. The water table is present at a depth of approximately 2 to 3 feet bgs at this location. Well US6S is screened in the surficial sand at a depth of approximately 36 to 42 feet bgs. Well US6I is screened within the clay-rich diamict at a depth of approximately 59 to 63 feet bgs; the annular seal extends to a depth of approximately 57 feet bgs. The

surficial sand is present to a depth of approximately 52 feet bgs at this location (See Geologic Cross Section A-A', Figure 13).

In summary, a very low concentration of 1,2-DCE was detected at the water table well W6S, but no VOCs were detected in the deeper well US6S, which is also screened in the surficial sand. TCE was detected in well W6I, screened in the upper portion of the clay-rich diamict. No VOCs were detected in deepest well, US6D, screened in the deep sand and gravel aquifer (see Section 4.7.2.3).

Carbon disulfide was detected at 0.8 ug/L in well G11S, located in the northwest corner of the old landfill. Carbon disulfide was not detected in any other monitoring well sample or surface water sample.

No SVOCs or pesticides/PCBs organics were detected in groundwater samples obtained from the surficial sand.

The U.S.EPA Secondary Maximum Contaminant Levels (SMCLs) for iron and manganese were exceeded at all of the on-site surficial sand wells sampled, except for well US6I. Iron concentrations in these wells ranged from 2,480 to 3,600 ug/L. Manganese concentrations ranged from 20.3 ug/L at well US6I to 745 ug/L at well W6S.

In addition to those metals naturally present in all samples from the surficial sand wells (barium, calcium, iron, magnesium, manganese, potassium, and sodium), arsenic, chromium, and nickel were detected in one sample each. Arsenic was detected in well US6I at 9.5 ug/L, which is above the background value, but below the MCL of 50 ug/L. Chromium was detected in well W6S at 4.4 ug/L, which is below the MCL of 100 ug/L. Chromium background data were not available. Nickel was detected in well US4S at 9.7 ug/L, which is below both the MCL and the background value.

Indicator parameter results for the on-site surficial sand wells were elevated above the background value (as defined in Section 4.5.2) for ammonia at well W5S, which is located in the southeastern corner of the old landfill. The indicator parameter sulfate was elevated above the background value at wells US4S and W6S. Hardness, alkalinity, and chloride results were all elevated above then background values, as they were throughout most of the groundwater samples. Total dissolved solids values exceeded the SMCL at most on-site surficial sand groundwater locations as well. Refer to Table 4-8 for a summary of indicator parameter results and background values.

4.7.2.2 Off-Site Surficial Sand - The off-site surficial sand monitoring wells sampled during the RI include well US1S outside the southeastern corner of the

new landfill, wells US3S and W4S, located outside the southwestern corner of the old landfill and wells W3SA and W3SB, located south of the old landfill. Well US3I is screened in the clay-rich diamict.

No VOCs, SVOCs, or pesticides/PCBs were detected in the off-site monitoring wells screened in the surficial sand.

Well nest W3SA/W3SB/W3D was installed in the wetland south of the landfill to evaluate water quality in the surficial sand (both at the water table and at the base of the surficial sand) and in the deep sand and gravel aquifer. Wells W3SA and W3SB are both screened in the surficial sand: Well W3SA at a depth of approximately 6 to 16 feet bgs and well W3SB at a depth of approximately 25 to 29.5 feet bgs. The bottom of the surficial sand is present at a depth of approximately 29.5 feet bgs at this location (See Geologic Cross Section A-A', Figure 13). As indicated above, VOCs are not present in any of these wells.

The U.S. EPA SMCLs for iron and manganese were exceeded at wells. Wells US1S, US3S, and W3SB exceeded the SMCLs for iron and wells US3S, W3SB, and W4S exceeded the SMCL for manganese. Additional metals detected in the off-site surficial sand wells include arsenic, chromium, cobalt, copper, nickel, and zinc. Of the metals detected, barium, calcium, magnesium, potassium, and zinc were detected above the background values. Zinc was detected in wells W4S and W3SB, both located south of the old landfill.

Indicator parameter results for the shallow off-site surficial sand wells are summarized in Table 4-8. The ammonia results were elevated above the background value for well W4S, as were the sulfate results for well W3SB. The hardness, alkalinity, and chloride results for the shallow off-site surficial sand wells were all elevated above the background value, as they were throughout most of the groundwater samples collected at the site. Total dissolved solids exceeded the SMCL at well US3I and in the field duplicate of well W4S.

4.7.2.3 On-Site Deep Sand and Gravel Aquifer - The on-site deep sand and gravel aquifer monitoring wells sampled during the RI include well G11D at the northwestern corner of the old landfill, well US4D at the southwestern corner of the old landfill, well US6D at the southeastern corner of the old landfill, and well W7D east of the new landfill.

No VOCs, SVOCs, or pesticides/PCBs were detected in the on-site monitoring wells screened in the deep sand and gravel aquifer.

Historically, TCE had been found at well US6D, at concentrations of 0.5 to 0.7 ug/L. These concentrations are less than ten percent of Contract Required

Quantitation Limits (CRQLs) specified in the QAPP. TCE was not detected above the CRQL in the current RI sampling round.

The U.S. EPA MCL for cadmium of 5 ug/L was exceeded by the sample from well G11D (5.6 ug/L). The U.S. EPA SMCLs for iron and manganese were exceeded by the sample from the on-site deep sand and gravel aquifer wells US6D for iron and W7D for manganese. In addition to those metals considered naturally occurring, arsenic, chromium, and thallium were detected in these samples. Cadmium, calcium, and magnesium were detected in well G11D at concentrations above the background value. Background data was not available for thallium which was only detected in well G11D.

Indicator parameter results for chloride, alkalinity, and hardness for the on-site deep sand and gravel aquifer wells were lower overall when compared to the surficial sand and off-site deep sand and gravel aquifer well results. Total dissolved solid results exceeded the SMCL for US4D and US6D.

4.7.2.4 Off-Site Deep Sand and Gravel Aquifer - Off-site deep sand and gravel aquifer monitoring wells sampled during the RI include well US1D located outside the southeastern corner of the site, well US3D located outside of the southwestern corner of the old landfill, and well W3D located south of the old landfill.

Vinyl chloride at 28 ug/L, and 1,2-DCE at 11 ug/L were detected in the sample from monitoring well US3D, located approximately 250 feet northwest of US4S and US4D. Historically, VC was detected in 1990 at a concentration of 12.3 ug/L at this location. A summary of VOC results is presented in Table 4-4.

Well US3D is screened at a depth of approximately 77 to 83 feet bgs, in the upper portion of the deep sand and gravel aquifer (See Geologic Cross Section A-A', Figure 13). As indicated in Section 4.7.2.2, no VOCs, SVOCs, or pesticides/PCBs were detected in wells US3S and US3I, screened in the surficial sand and clay-rich diamict, respectively at this location.

SVOCs and pesticides/PCBs were not detected in any of the off-site monitoring wells screened in the deep sand and gravel aquifer.

The U.S. EPA SMCLs for iron and manganese were exceeded at all off-site deep sand and gravel aquifer wells (except well US3D for manganese). In addition to those metals considered naturally occurring, chromium, nickel, and zinc were also detected. Barium, calcium, magnesium and zinc were detected in samples above the background values at wells US3D and W3D.

Hardness, alkalinity, and chloride analytical results for the off-site wells screened in the deep sand and gravel aquifer were all elevated above the background values, as they were throughout most of the groundwater samples. Total dissolved solids concentrations measured in these off-site deep sand and gravel aquifer wells also exceeded the SMCL at all locations.

4.7.3 Village of Antioch Water Supply Wells

Groundwater samples were collected from the Village of Antioch water supply wells No. 3 (VW3) and No. 5 (VW5). The analytical results for these samples are summarized in Table 4-9. Also included is a review of the historical VOC data from 1984 through 1989 and from August 1992 through May 1993 for the Village's water supply well No. 4 (VW4), located approximately 200 ft. west of the southwest corner of the old landfill. These analytical results for Well No. 4 are summarized in Table 4-10.

The VOC carbon disulfide was detected in village well VW5 at 0.6 ug/L. Carbon disulfide was not detected in landfill leachate. No other VOCs were detected in village wells VW3 and VW5.

The Village of Antioch water supply well VW4, as required by Illinois law, was sampled during 1992 and 1993 for VOCs listed under the Safe Drinking Water Act (SDWA) by EPA method 524.2 (a gas chromatograph/mass spectrometer (GC/MS) method). VOCs detected include cis-1,2-DCE, chloromethane, and chloroform. Chloromethane and chloroform can be formed during chlorination of groundwater and many not be related to an external contaminant source. Cis-1,2-DCE was reported above the detection limit of 0.5 ug/L intermittently during 1992 and 1993, at concentrations of 0.5 to 0.8 ug/L (below the MCL of 70 ug/L). Chloromethane was reported above the detection limit of 1.0 ug/L in July 1992 (2.2 ug/L) and November 1992 (1.3 ug/L). Chloroform was detected once, at an estimated concentration of 0.9 ug/L (below the reported detection limit of 1.0 ug/L). In addition, historical VOC analytical results for samples collected from 1984 through 1990 have also been included in Table 4-10.

SVOCs detected in the village water supply wells VW3 and VW5 include 2-methylphenol (o-cresol) at an estimated concentration of 0.5 ug/L in VW5, and 4-chloroaniline, at an estimated concentration of 0.7 ug/L in VW3. 4-Chloroaniline has a variety of industrial uses, as a dye intermediate, and in agricultural chemicals. The source of these compounds is not clear. 4-chloroaniline was not detected in any other samples collected at the site. 2-methylphenol was detected in one leachate sample and no other samples.

Note that concentrations below the Contract Required Quantitation Limit (CRQL) are considered estimated (i.e., flagged with the laboratory qualifier "J" as defined

in Appendix P). This is because the concentration is below the linear range of the the calibration performed during analysis. In organic analysis, the CRQL (the concentration that can be reliably detected by a number of different laboratories at a specific degree of confidence) is reported instead of the instrument detection limit (the instrument-specific, statistically-determined minimum concentration that can be detected). Detects below the CRQL are more susceptible to error than detects above the CRQL.

Total metals analysis indicated that the aluminum and iron concentrations detected in the Village water supply wells exceeded the U.S. EPA SMCLs. Well VW5 contained an aluminum concentration of 55 ug/L, which is above the SMCL of 50 ug/L for aluminum. The 300 ug/L SMCL for iron was exceeded in samples obtained from Village water supply wells VW3 (646 ug/L), and VW5 (1,100 ug/L). Iron exceeded the typical background value in the sample obtained from Village water supply well VW5. The aluminum exceedence may be due to aluminum in suspended solids present in the samples. The Village water supply well samples are not filtered unlike monitoring well samples which are filtered. These analytical results were below the typical background value for aluminum.

4.7.4 Private Residence Wells

Four private residence wells, located just east of the site, were sampled during June and July, 1993. The analytical results for these private wells are summarized in Table 4-9.

No VOCs or pesticides/PCBs were detected in any of the private well water samples.

The SVOC 2-methyl phenol (o-cresol) was detected at an estimated concentration of 0.9 ug/L in the sample obtained from private well PW2.

Metals analysis indicated that aluminum and iron concentrations exceeded the U.S. EPA SMCLs in the private well samples. Private well PW3 contained aluminum at 75 ug/L, which is above the SMCL of 50 ug/L for aluminum. The 300 ug/L SMCL for iron was exceeded in private wells PW1 (3,050 ug/L), PW2 (643 ug/L), and PW3 (549 ug/L).

Additional total metals concentrations detected in samples from the private wells include cobalt in private well PW2 only; and copper, lead, manganese, vanadium in private well PW1 only. Zinc was detected at levels above the background value in private wells PW1, PW5, and PW3. Of all of the metals detected in the unfiltered private well samples, chromium, lead, and vanadium were not detected in dissolved (filtered) metals analysis of samples from monitoring wells US1S, US1D, and W7D, which are located in the same general area on the eastern edge

of the site. Copper, detected in private well PW1 at 26 ug/L, was also found in one of the groundwater monitoring well samples (US1S at 4.4 ug/L). Barium, copper, iron, magnesium, manganese, and zinc concentrations detected in the private well samples exceeded the typical background values for these total metals.

4.7.5 Surface Water

Surface water samples were collected at three locations in Sequoit Creek. Sample SWS101 was collected upstream of the site at the southeast corner of the new landfill. Sample SWS201 was collected at the southwest corner of the landfill, south of the bridge that crosses the creek at this location. Sample SWS301 was collected at the northwest corner of the old landfill.

The VOCs that were detected in these surface water samples are limited to detects of 4-methyl-2-pentanone and 2-hexanone, at 2 and 3 ug/L respectively, in sample SWS301. These compounds were not found in the field duplicate sample collected at this location.

No SVOCs or pesticides/PCBs were detected in these surface water samples obtained from the site. These surface water samples were not analyzed for the indicator parameters that the groundwater samples from the site were analyzed for.

A summary of all reported metals detected is presented in Table 4-7. Because the surface water samples were analyzed for total metals (i.e., samples were not filtered), the metals concentrations that were detected are generally higher than those detected in the groundwater samples from the site. Aluminum, which is strongly adsorbed to solids, was detected in all of the unfiltered surface water samples. Antimony, detected at 27.6 ug/L in sample SWS301, was not detected in any other groundwater, surface water, surface soil, or leachate samples from the site. Cadmium, chromium, copper, lead, and zinc were also detected in the surface water samples.

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CONTAMINANT FATE AND TRANSPORT

This section provides a review of physical and chemical mechanisms that may affect the behavior of site contaminants identified in Section 4. Migration pathways are identified, and the fate and migration of specific contaminants found in groundwater and soils are discussed.

5.1 SUMMARY OF FINDINGS

Chemical constituents detected at the site consist primarily of chlorinated organic solvents in the groundwater. These organic compounds are primarily chlorinated alkenes, including trichloroethene (TCE), 1,2-dichloroethene (1,2-DCE), and vinyl chloride (VC). These compounds were also detected in leachate from the landfill. The concentrations of these compounds as they travel from the source area are expected to be reduced through physical and chemical mechanisms, including dilution, adsorption/desorption, biodegradation, and volatilization.

A summary of the physical and chemical properties of the compounds detected at the site, including molecular weight, water solubility, density, Henry's Law constant, organic carbon/water partition coefficient (K_{oc}), Log octanol/water partition coefficient (K_{ow}), vapor pressure, and relative retardation factor, is presented in Table 5-1.

5.2 PHYSICAL/CHEMICAL ATTENUATION MECHANISMS

The primary mechanism affecting the migration of contaminants in groundwater is the physical flow of the groundwater. As contaminants are carried away from the source by this flow, dilution will occur, resulting in the attenuation of the contaminant concentration. In addition, the fate and migration of organic and inorganic contaminants in the subsurface environment can be affected by chemical and physical mechanisms. These mechanisms may cause a contaminant to remain in solution, precipitate out of solution, be adsorbed to a surface, or transform or degrade into another compound. The following discussion summarizes each of these potential mechanisms and their effects.

5.2.1 Dilution/Attenuation

A non-reactive species introduced into groundwater or surface water would decrease in concentration as it is transported away from the source. This dilution/attenuation of a chemical is independent of any chemical mechanism affecting concentration over distance. Chloride is a non-reactive indicator species affected primarily by dilution.

5.2.2 Adsorption/desorption

Organic contaminants may be adsorbed or desorbed by organic matter and soil, strongly influencing the rate of migration. Strongly adsorbed contaminants are relatively immobile and will not be leached or transported. The amount of a chemical that will be adsorbed is a function of the properties of the chemical in question, the geological matrix, and the hydrological environment.

Hydrophobic organic compounds dissolved in aqueous solutions will tend to adsorb onto solid phases that the water contacts. The amount of contaminant that is adsorbed is a function of soil grain size, mineral composition, organic content, solute composition, and solid concentration. However, of the variety of soil components that can influence rates of adsorption, organic carbon content is generally the most significant. Based on a chemical's organic carbon/water partition coefficient (K_{oc}) and the soil organic carbon content (f_{oc}), the relative affinity of a compound for a soil matrix can be estimated. This in turn can provide an estimate of the transport rates for various chemicals. The retardation factor of a chemical describes the effect of sorption in decreasing the rate of contaminant transport in the liquid phase, relative to a non-reactive species ($R_f = 1$). A nonreactive species, such as chloride, would have a transport rate equal to the groundwater flow. A secondary influence of adsorption on the fate of groundwater contaminants is the retention of organic chemicals near the source area, where biological and chemical degradation may be enhanced by the presence of a carbon source or bacteria.

The retardation factor is calculated as follows:

$$Rf = 1 + (Pb/n) \times K_d$$

Where:

Rf = Retardation Factor (unitless)

Pb = aquifer bulk density (g/m³)

n = effective porosity (unitless)

K_d = distribution coefficient (ml/g)

and

$$K_d = K_{oc} \times f_{oc}$$

where:

K_{oc} = organic carbon partition coefficient

f_{oc} = organic carbon fraction

Aquifer bulk density (Pb) and effective porosity (n) are assumed to be 1.8 g/cm³, and 0.3; typical values for sand and gravel soils. The organic carbon fraction (f_{oc}) is assumed to be 0.1%. Given the differences of the various geological units present at the Site, these values were assumed to represent conditions in the aquifer and provide estimates to allow a comparison of the effective rate of transport for various chemicals detected at the HOD Landfill Site. Retardation factors calculated in this manner are presented in Table 6-1, along with chemical and physical properties of chemicals detected at the site. Retardation factors for 1,2-dichloroethene and 1,4-dichlorobenzene are 1.23 and 11.2 respectively. Therefore, 1,2-dichloroethene would be expected to travel more quickly through the aquifer than 1,4-dichlorobenzene. PAHs such as benzo(b)fluoranthene, with retardation factors 1,000 times higher, would be expected to move very slowly.

Inorganic elements have multiple valence states exhibiting different adsorption behavior. Hydrogeochemical conditions affect how each chemical contaminant reacts. Adsorption will vary depending on pH and Eh conditions, and on the competing ion species present. Geological matrix components such as hydrous metal oxides (Fe, Mn), amorphous aluminosilicates, layer lattice silicates (clays), and organic matter, all provide significant adsorptive surfaces. These surfaces adsorb contaminants through a pH dependent charge. Decreasing groundwater pH generally increases positive charge and favors anion retention, while increasing pH favors cation adsorption. Uncomplexed ions tend to be preferentially adsorbed over complexed ions. Although considerable descriptive and qualitative information is available for some elements, it is not possible to predict adsorption behavior quantitatively based on mineralogy and groundwater composition.

(Battelle, 1984). The synergistic effect of pH, Eh, complexing ions, and competing ions on adsorption varies between contaminants and matrix materials and requires further study. However, generalizations and broad groupings of elements with similar geochemical behavior may be made. Accordingly, metals in groundwater do not appear to present a significant problem at the Site.

5.2.3 Biodegradation

Biodegradation may be an important fate mechanism for organic constituents under proper conditions. Biodegradation can result in partial or complete reduction of contaminant concentrations, and the production of microbial cells, water and carbon dioxide. The contaminant is transformed in the presence of an electron acceptor; oxygen in aerobic conditions, and nitrogen, sulfate or carbon dioxide in anaerobic environments. Biodegradation of BETXs (aromatic hydrocarbons) may occur under aerobic conditions present in the vadose zone. Other persistent contaminants may resist biodegradation.

Microbially mediated reductive dechlorination of chlorinated alkenes and alkanes may take place in groundwater systems (Bouwer and McCarty 1983, 1983a, Parsons et al. 1987, 1987a). Thus, the chlorinated alkene tetrachloroethene will degrade to trichloroethene, which will further degrade to 1,2-dichloroethene and finally chloroethene, better known as vinyl chloride. 1,1,1-Trichloroethane will degrade to 1,2-dichloroethane and on to chloroethane. The rate of degradation is related to the availability of a non-chlorinated carbon source (as a nutrient for the bacteria), pH, temperature, compound concentration, and the presence of microbial toxicants. Sufficient concentrations of the compound must be available to support bacterial growth. Biodegradation is likely to occur more readily in the surficial sand than in the deep sand and gravel aquifer.

5.2.4 Oxidation/Reduction

Groundwater systems through hydrochemical and biochemical reactions tend towards oxygen depletion and reducing conditions. This trend is offset by oxidation of organic matter catalyzed by microorganisms. The general decrease in dissolved oxygen produces H^+ ions. This decrease in pH is often offset by the reaction of the H^+ with various minerals. When all dissolved oxygen is consumed (DO generally less than 0.05 mg/L), and other oxidizing agents are also consumed, the environment may become so strongly reducing that organic compounds may undergo anaerobic degradation. For this to occur, the microorganisms must have sufficient consumable material (organic matter), nutrients (nitrogen, sulfur, phosphorus, some metals), and climatic stability (temperature).

In groundwater systems, pH and the redox potential (Eh, the the energy gained in the transfer of 1 mmol of electrons from an oxidant to H_2) are interdependent. Many redox reactions proceed at a slow rate, and may be irreversible.

5.2.5 Volatilization

Loss of organic contaminants from the site through volatilization is dependent on site factors including soil porosity, moisture content, nature of the ground surface, and climatic conditions such as temperature and wind speed. Volatilization is also dependent on contaminant specific properties such as Henry's Law constant and diffusivity. The process involves desorption of the contaminant from the soil into the soil water, diffusion into the water, interphase mass transfer between the water and the air, diffusion out of the soil pores and into the ambient air.

5.2.6 Precipitation

The solubility of metal species present in the aquifer matrix controls precipitation of metal contaminants in groundwater. The thermodynamic behavior of various species may be used to predict the most stable phase that will form in environment. The evidence for the existence of solubility-controlling solid phases is often indirect, such as the comparison of ion activity products to solubility products. Hydroxide and carbonate solids, stable at neutral to high pH values, often control precipitation rates.

5.2.7 Hydrolysis

Hydrolysis reactions occur between water and an ionic species in solution. Salts of weak acids and bases hydrolize and may affect the overall attenuation of various contaminants. Hydrolysis reactions may be catalyzed by acids, bases and selected metals. Hydrolysis is not a primary fate of contaminants, but may occur in specific environments.

5.3 POTENTIAL MIGRATION PATHWAYS

Contaminants introduced to the environment may migrate through a variety of pathways to reach potential receptors. The contaminant may contact and be dispersed by groundwater and discharged to a surface water body, or be volatilized, emitted from the surface, and dispersed to the air.

5.3.1 Groundwater/private wells

Groundwater provides the primary migration pathway for contaminant transport at the site. The extent of migration of these contaminants in the groundwater is dependent on the interrelationship between site-specific geological and hydrochemical conditions, and the physical and chemical properties of the contaminant itself. In addition, contaminants may be entering the groundwater

from sources other than the site, further complicating any attempt to describe the fate and transport of contaminants detected at the site.

Physical and chemical properties that may affect the migration of the chlorinated VOCs present at the site include dilution, adsorption/desorption, absorption, and biodegradation. No single mechanism appears to dominate contaminant fate and transport at the site. Varying retardation factors may be slowing the transport of specific compounds, while biodegradation rates likely vary at shallow versus deep depths. Variations in the water table level may be releasing contamination from a source area in 'slugs', as opposed to a steady state release. Changes in the water table may also effect the direction of the contaminant flow.

The chlorinated VOCs detected at the site appear to be present only in the dissolved phase based on the relatively low concentrations detected. At well nest W3SA/W3SB/W3D, there were no VOCs detected at any of the wells including well W3SB screened at the base of the surficial sand. Although low levels of VOCs were detected at wells W6S and US6I at well nest W6S/US6S/US6I/US6D, there is no evidence that free phase non-aqueous phase liquid (NAPL) is present.

Chlorinated alkenes (1,2-DCE and VC) detected in on-site surficial sand wells (US4S, W5S, and W6S) or at clay-rich diamict well US6I (TCE) were not detected in off-site surficial sand wells. It is likely that any contaminants present on-site in the surficial sand are either biodegraded or intercepted by Sequoit Creek (groundwater discharge zone) before they can migrate off-site.

Likewise, chlorinated alkenes detected in on-site surficial sand wells were not detected in the corresponding on-site deep sand and gravel aquifer wells. This further suggests that the clay-rich diamict, because of its thickness and low permeability (See Section 3.7.2), acts as a barrier to contaminant migration from the surficial sand to the deep sand and gravel aquifer.

The source and migration pathway for the VC (28 ug/L) and 1,2-DCE (11 ug/L) detected at off-site deep sand and gravel well US3D is not clear. As indicated above, VOCs were not detected in any other deep sand and gravel monitoring wells or off-site surficial sand wells. Vinyl chloride (well W5S: 19 ug/L) and 1,2-DCE (well US4S: 35 ug/L; well W6S: 2 ug/L) were detected on-site in the surficial sand. However, based on the relatively low concentrations detected on-site and the low hydraulic conductivity of the clay-rich diamict, it appears unlikely that these VOCs would have migrated from the landfill, through the clay-rich diamict, and into the deep sand and gravel aquifer. The potential exists that another source (See Section 2.2.10 and Appendix G) may be contributing to VOCs present at Well US3D.

5.3.2 Surface Water

Surface water in Sequoit Creek may potentially be contaminated by releases of leachate either through seeps or from contaminated groundwater. Low concentrations of ketones (2 ug/L of 4-methyl-2-pentanone and 3 ug/L of 2-hexanone) were detected (but not confirmed in the field duplicate) downstream of the landfill in sample S301, collected near the northwest corner of the old landfill. Given the concentration of ketones in the leachate, 2-butanone and acetone, detected at concentrations up to 19,000 ug/L, would more likely be present in surface water contaminated by leachate than 4-methyl-2-pentanone and 2-hexanone, which were found at a range of 14 to 450 ug/L.

Ketones would be expected to undergo volatilization in water, as well as direct photolysis; 4-methyl-2-pentanone degraded by direct photolysis produces acetone. Ketones may also be susceptible to aerobic biodegradation.

5.3.3 Surface Soils

Surface soils were collected at locations with obvious signs of staining or leachate seepage. Contaminants identified in these surface soils include aromatics, phthalates, and PAHs. Aromatic compounds such as benzene, toluene, and xylene undergo volatilization and biodegradation in soils. While very mobile in groundwater, aromatics were not found in surface waters or groundwaters.

Phthalates, detected at high concentrations in the surface soil, are strongly adsorbed to organic carbon (the surface soils have an average total organic carbon concentration of 2.6 %), and thus will strongly resist leaching into the groundwater. Biodegradation may occur in surface soils to a limited extent. Phthalates were not detected in surface waters or ground waters.

PAHs found in the surface soils are strongly adsorbed to soils and have low water solubilities, and are not expected to leach in the water. Under aerobic conditions PAHs will undergo biodegradation. PAHs were not detected in groundwater and surface water samples.

5.3.4 Air (Landfill Gas)

VOCs detected in the landfill gas include chlorinated alkanes, chlorinated alkenes, ketones, aromatics and freons. The gas is currently burned off in passive flares, destroying most of these compounds in the process. Most VOCs present in the landfill gas that are released to the ambient atmosphere will be diluted with that ambient air, and undergo decomposition through direct photolysis.

CONCLUSIONS

The field investigation has generally provided sufficient information to prepare the RI Report. However, some additional analysis and review of the existing information will be necessary to complete the report. The following is a list of analysis to be performed during the preparation of the RI report:

- The geotechnical data and physical descriptions of the cover and subsoils will be further evaluated to confirm the integrity, geotechnical properties, and quality of the existing cap. The information will also be used to calculate infiltration rates through the existing cap.
- Additional rounds of water level measurements will be obtained to confirm the results of the two rounds presented in this Technical Memorandum.
- The results of the ecological characterization will be utilized in preparing the risk assessment for the site.
- All of the geologic and hydrogeologic data collected to date will be used to revise or expand the conceptual model of the site, as necessary.
- All of the chemical and hydrogeologic data will be used to determine the nature and extent of contamination and the fate and transport of contaminants.

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TABLE 1-1

**LIST OF ACRONYMS AND ABBREVIATIONS
H.O.D. LANDFILL SITE RI**

<u>Acronym</u>	<u>Description</u>
1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,2-DCPA	1,2-dichloropropane
1,2-DCE	1,2-dichloroethene
1,1-DCE	1,1-dichloroethene
AOC	Administrative Order by Consent
ARAR	Applicable or Relevant and Appropriate Requirement
ASTM	American Society of Testing Materials
ATV	All Terrain Vehicle
BETX	Benzene, Ethylbenzene, Toluene, and Xylene
BRA	Baseline Risk Assessment
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
CRQL	Contract Required Quantitation Limit
DCE	1,2-dichloroethene
FS	Feasibility Study
HELP Model	Hydrologic Evaluation of Landfill Performance Model
I.D.	Inner Diameter
MCL	Maximum Contaminant Level
MSL	Mean Sea Level
NCP	National Contingency Plan
NPL	National Priorities List
O.D.	Outer Diameter
PCB	Polychlorinated Biphenyls
PID	Photoionization Detector
PQL	Practical Quantitation Limit
PSER/TS	Preliminary Site Evaluation Report/Technical Scope

<u>Acronym</u>	<u>Description</u>
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
Site	H.O.D. Landfill Site
SQL	Sample Quantitation Limit
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TDS	Total Dissolved Solids
TIC	Tentatively Identified Compound
TOC	Total Organic Carbon
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WEG	Water Elevation Gauge

Table 3-1
Soil Testing Results
From
Landfill Cap Evaluation
H.O.D. Landfill RI/FS

TEST PIT NUMBER	LAYER	DEPTH (inches)	GRAIN SIZE	ATTERBURG LIMITS LL/PI	MOISTURE CONTENT (%)	NATURAL DENSITY (lbs/cu ft)	LABORATORY PERMEABILITY (cm/sec)	PROCTOR ANALYSIS (lbs/cu ft)
1	D	24-31	CL	34/15	18.7	--	--	--
2	D	34-40	CL	31/14	14.3	--	--	--
3	D	26-36	CL	38/21	19.4	--	--	--
4	E	41-55	CL	33/16	17.6	--	--	--
5	C	17-20	CL	33/16	13.7	--	--	--
6	D	41-65	CL	38/19	18.2	--	--	--
7	B	8-35	CL	46/25	23.8	--	--	--
8	D	56-82	CL	34/16	14.8	--	--	--
9	E	29-84	CL	34/17	33.6	--	--	--
10	D	30-62	CL	33/16	16.1	--	--	--
10-DUP	D	30-62	CL	31/15	15.6	--	--	--
1	--	18-32	--	--	--	115.5	--	--
2	--	25-38	--	--	--	109.3	--	--
3	--	26-40	--	--	16.2	--	9.03E-09	--
4	--	30-42	--	--	19.6	--	1.04E-08	--
5	--	15-30	--	--	--	117.7	--	--
6	--	39-53	--	--	--	116.4	--	--
7	--	35-50	--	--	18.6	--	3.70E-08	--
8	--	58-70	--	--	--	128.3	--	--
9	--	29-42	--	--	14.5	--	3.00E-08	--
10	--	43-55	--	--	--	121.9	--	--
2	--	21-31	--	--	--	--	--	126
3	--	24-34	--	--	--	--	--	126
6	--	16-26	--	--	--	--	--	130
10	--	29-39	--	--	--	--	--	132

Note:-- denotes not applicable

CCH/ech/DAP

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Table 3-2
 Boutwell Apparent
 Vertical Conductivity
 H.O.D. Landfill RI/FS

BOUTWELL NUMBER	APPARENT VERTICAL CONDUCTIVITY (cm/sec)
1	1.02E-05
2	3.67E-08
3	4.22E-08
4	7.77E-08
5	9.08E-07
6	5.97E-08
7	1.04E-07
8	8.86E-06
9	1.61E-05
10	4.69E-08

CCH/cch/DAP

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TABLE 3-3

**Landfill Cap Thickness and Vertical
Extent of Refuse
H.O.D. Landfill RI/FS**

Boring	Depth to Refuse (ft)	Depth to Base Material (ft)	Cap Thickness (ft)	Refuse Thickness (ft)
LP1	5.0	23.0	5.0	18.0
LP2	4.0	40.0	4.0	36.0
LP3	5.0	28.5	5.0	23.5
LP4	4.0	40.0	4.0	36.0
LP5	4.5	51.0	4.5	46.5
LP6	4.5	40.0	4.5	35.5
LP7	5.0	62.0	5.0	57.0
LP8	7.0	70.5	7.0	63.5
LP9	8.0	68.5	8.0	60.5
LP10	5.0	28.5	5.0	23.5
LP11	9.0	33.0	9.0	24.0
LP12	4.5	25.5	4.5	21.0
LP13	5.0	17.0	5.0	12.0
LP14	4.5	23.5	4.5	19.0
TP1	6.5	--	6.5	--
TP2	5.8	--	5.8	--
TP3	7.3	--	7.3	--
TP4	5.2	--	5.2	--
TP5	4.1	--	4.1	--
TP6	5.4	--	5.4	--
TP7	5.0	--	5.0	--
TP8	6.8	--	6.8	--
TP9	7.0	--	7.0	--
TP10	5.2	--	5.2	--
B1	5.0	8.3	5.0	3.3
B2	4.0	10.0	4.0	6.0
B3	4.0	10.5	4.0	5.5
B4	4.0	13.5	4.0	9.5
B5	5.0	17.0	5.0	12.0
GW1	5.0	42+	5.0	37.0+
GW2	5.0	47.0+	5.0	42.0+
GW3	5.0	45.0+	5.0	40.0+
GW4	5.0	45.0+	5.0	40.0+
GW5	5.0	55.0+	5.0	50.0+
GW6	5.0	41.0+	5.0	36.0+
GW7	5.0	48.0+	5.0	43.0+
GW8	5.0	48.0+	5.0	43.0+
GW9	5.0	48.0+	5.0	43.0+
GW10	5.0	38.0+	5.0	33.0+
GW11	5.0	40.0+	5.0	35.0+
GW12	5.0	22.0+	5.0	17.0+
GW13	5.0	45.0+	5.0	40.0+
GW14	5.0	43.0+	5.0	38.0+
Notes:				
+ Base Material not encountered. Thickness of refuse may be greater than actual Thickness represented.				
-- Base Material not encountered in Test Pits.				

TABLE 3-4

Lanfill Gas Probe
Field Screening Results
June 4, 1993
H.O.D. Landfill RI/FS

Probe Number	% Methane	% Carbon Dioxide	% Oxygen
LP01	0.0	0.4	20.5
LP06	67.7	32.2	0.1
LP07	65.4	34.4	0.1
LP08	67.6	31.1	0.1
LP11	72.3	26.7	0.1
GP3	0.0	0.0	20.9
GP4A	0.0	0.0	20.8
GP5A	0.0	0.0	20.9

TABLE 3-5
Sequoit Creek Staff Gage and
Stand Pipe Water Levels
6/8/93-6/9/93
H.O.D. Landfill RI/FS

Staff Gauge (PSG) and Stand Pipe (SC)	Ground Elevation (ft msl)	TOC Elevation (ft msl)	6/8/93-6/9/93		8/18/93-8/19/93		
			Total Depth (ft)	Groundwater Level (ft)	Groundwater Elevation (ft msl)	Groundwater Depth to Water	Groundwater Elevation
PSG-1		763.79	NA	1.7	762.16	1.8 ^b	762.26
SC-1A	764.7	766.84	14.9	4.23	762.61	4.7	762.14
SC-1B	766.4	769.34	24	6.22	763.12	7.21	762.13
SC-1C	762.9	765.44	---	---	---	3.25 ^b	762.19
SC-1D	762.94	766.39	---	---	---	4.26 ^b	762.13
PSG-1 ^a		763.79	NA	2.98	763.44	NA	NA
SC-1A ^a	764.7	766.84	15.1	4.11	762.73	NA	NA
SC-1B ^a	766.4	769.34	23.95	5.16	764.18	NA	NA
SC-1C ^a	762.9	765.44	18	2.57	762.87	NA	NA
SC-1D ^a	762.94	766.39	22.35	3.22	763.17	NA	NA
PSG-2		762.53	NA	2.1	761.3	2.04	761.24
SC-2A	763.2	765.09	---	2.91	762.18	3.59	761.5
SC-2B	766	767.24	20	4.8	762.44	5.5	761.74
SC-2C	763.2	764.51	15	2.14	762.37	2.69 ^b	761.82
SC-2D	763.4	764.77	15	2.4	762.37	2.92 ^b	761.85
PSG-3 ^a		762.86	NA	2.3	761.83		
PSG-3		762.86	NA	1.64	761.17	1.56	761.09
SC-3B	769.9	770.6	17.25	8.71	761.89	9.19	761.4
SC-3C	767.7	770.26	17.08	8.31	761.95	8.75	761.51
SC-3D	767.1	769.77	13.85	*5.09	764.68	Broken	769.77
PSG-4		762.45	NA	1.4	760.52	1.8	760.92
SC-4A	768.8	770.22	---	9.36	760.86	10.35	759.87
SC-4B	768.1	770.44	30	9.6	760.84	10.28	760.16
SC-4C	765.8	768.53	20.17	7.63	760.9	8.31	760.22
SC-4D	766.3	769.6	24	8.68	760.92	9.42	760.2
S101	762.5	765.49	8.9	2.25	763.24	2.94 ^b	762.55
Surface Water Level at EPA Well Point (S101)		765.49	NA	2.45	763.04	Dry ^b	765.49

Notes:

-- = Measurement Not Collected

NA = Not Applicable

* = Stand Pipe Broken

TOC = Top of Casing

a = Measurements obtained on 6/9/93

b = Measurements obtained on 9/3/93

(1) = Water Levels collected by Western Gulf Coast Laboratories

Elevations Surveyed by Gentile and Associates, Inc. for Warzyn on June 28 through July 1, 1993

TABLE 3-6
Sequoit Creek Flow Measurements
Sequoit Creek
H.O.D. Landfill RI/FS

June 8, 1993

PSG 1

<u>Station No.</u>	<u>Depth of Water (ft)</u>	<u>Revolutions of Standard Meter</u>	<u>Elapsed Time (sec.)</u>	<u>Velocity⁽¹⁾ (ft/sec.)</u>	<u>Distance Between Stations (ft)</u>	<u>Area of Station⁽²⁾ (ft²)</u>	<u>Flow⁽³⁾ (ft³/sec.)</u>
1	1.50	0	90	0	1	1.50	None
2	1.68	0	60	0	1	1.68	None
3	1.70	0	60	0	1	1.70	None
4	1.40	0	60	0	1	1.40	None

No flow, the water is full (to the surface) of elodea weed.

PSG2

<u>Station No.</u>	<u>Depth of Water (ft)</u>	<u>Revolutions of Standard Meter</u>	<u>Elapsed Time (sec.)</u>	<u>Velocity⁽¹⁾ (ft/sec.)</u>	<u>Distance Between Stations (ft)</u>	<u>Area of Station⁽²⁾ (ft²)</u>	<u>Flow⁽³⁾ (ft³/sec.)</u>
1	0.62	4	60	0.34	1	0.62	0.214
2	0.93	3	60	0.31	1	0.93	0.288
3	1.11	0	60	0.00	1	1.11	None
4	1.38	13	60	0.67	1	1.38	0.925
5	1.70	8	60	0.49	1	1.70	0.833
6	1.03	9	60	0.53	1	1.03	0.546
7	1.11	3	60	0.31	1	1.11	0.344
8	1.00	0	60	0.00	1	1.00	None
							3.15

Total discharge is 3.15 ft³/sec.

TABLE 3-6
Sequoit Creek Flow Measurements
Sequoit Creek
H.O.D. Landfill RI/FS

PSG3

June 8, 1993

Station No.	Depth of	Revolutions	Elapsed	Velocity ⁽¹⁾	Distance	Area of	Flow ⁽³⁾
	Water	of Standard	Time		Between		
	(ft)	Meter	(sec.)	(ft/sec.)	(ft)	(ft ²)	(ft ³ /sec.)
1	0.23	0	60	0.00	1	0.23	None
2	0.41	0	60	0.00	1	0.41	None
3	0.51	13	60	0.67	1	0.51	0.343
4	1.30	13	60	0.67	1	1.30	0.871
5	1.48	16	60	0.78	1	1.48	1.15
6	1.51	13	60	0.67	1	1.51	1.01
7	1.45	19	60	0.89	1	1.45	1.29
8	1.21	12	60	0.64	1	1.21	0.774
9	1.21	3	60	0.31	1	1.21	0.375
10	1.05	1	60	0.24	1	1.05	0.252
11	1.00	0	60	0.00	1	1.00	None
12	0.75	0	60	0.00	1	0.75	None
13	0.46	0	60	0.00	1	0.46	None
Total discharge is 6.065 ft ³ /sec.							6.065

PSG4

Station No.	Depth of	Revolutions	Elapsed	Velocity ⁽¹⁾	Distance	Area of	Flow ⁽³⁾
	Water	of Standard	Time		Between		
	(ft)	Meter	(sec.)	(ft/sec.)	(ft)	(ft ²)	(ft ³ /sec.)
1	0.50	0	60	0.00	2	1.00	None
2	0.90	0	60	0.00	2	1.80	None
3	1.18	0	60	0.00	2	2.36	None
4	1.28	0	60	0.00	2	2.56	None
5	1.80	1	60	0.24	2	3.60	0.864
6	2.20	7	60	0.45	2	4.40	1.98
7	1.50	9	60	0.53	2	3.00	1.59
8	1.01	3	60	0.31	2	2.02	0.63
9	0.78	0	60	0.00	2	1.56	None
10	0.68	0	60	0.00	2	1.36	None
11	0.45	0	60	0.00	2	0.90	None
Total Discharge is 5.064 ft ³ /sec.							5.064

Notes:

1. Velocity is reported in feet per second (fps) calculated for the Standard Gurley meter by:
Velocity = $2.18(r) + 0.2$ where R = Revolutions/elapsed time (sec.)
2. Area of the station is reported in square feet (ft²) and calculated by multiplying the depth of water by the distance between stations.
3. Flow is reported in cubic feet per second (ft³/sec.) and calculated by multiplying velocity by the area of the station.
4. Total discharge is the sum of the individual stations flow, reported in ft³/sec.
5. The stations in the creek were located in the main channel of the creek. At locations PSG1 and PSG2 the channel from the bank to bank was wider than what is given on this table, but water was between 3 and 5 inches deep with cattails, thus flow measurement could not be made.

TABLE 3-7
Geotechnical Laboratory Results
H.O.D. Landfill RI/FS

Sample Point	Location	Depth (ft)	GSA ⁽¹⁾	P200 ⁽²⁾	L.L. ⁽³⁾	P.I. ⁽⁴⁾	Vertical Laboratory Permeability (CM/S)	USCS ⁽⁵⁾	Total Organic Carbon ⁽⁶⁾	Estimated Total Porosity
SU01	Surface	0-1	20.6/20.1/28.1/31.2	59.3	28	12	-	CL	-	-
SU02	Surface	0-1	4.9/32.4/47.0/15.7	62.7	33	8	-	CL	-	-
SU03	Surface	0-1	3.0/25.5/43.2/28.3	71.5	51	21	-	MH	-	-
SU04	Surface	0-1	0.5/60.5/23.2/15.8	39	26	10	-	SC	-	-
SU04 (D)	Surface	0-1	1.2/62.0/20.6/16.2	36.8	25	9	-	SC	-	-
SU05	Surface	0-1	6.6/33.1/33.5/26.8	60.3	29	12	-	CL	-	-
W2D	Profile	7-9	0.6/10.8/54.8/33.8	88.6	30	11	-	CL	-	-
W2D	Profile	29-31	-	-	-	-	1.50E-08	CL	3.6	0.38
W2D	Profile	32-34	3.3/2.3/33.3/61.1	94.4	38	19	-	CL	-	-
W2D (D)	Profile	32-34	0.1/2.0/33.4/64.5	97.9	38	19	-	CL	-	-
W2D	Screen interval	86-88	15.3/78.0/5.1/1.6	6.7	-	-	-	SP-SM	-	-
W3SB	Profile	18-20	10.4/80.7/5.7/3.2	8.9	-	-	-	SW-SM	-	-
W3D	Profile	36-38	-	-	-	-	1.70E-08	CL	1.64	0.24
W3D	Profile	38-40	5.0/44.0/28.8/22.2	51	18	6	-	CL/ML	-	-
W5S	Screen interval	7-9	18.5/41.4/30.6/9.5	40.1	63	NP	-	SM	11.7	-
W5S	Screen interval	12-14	8.8/70.6/16.5/4.1	20.6	-	-	-	SM	-	-
W6S	Screen interval	12-14	0.0/87.6/9.9/2.5	12.4	-	-	-	SM	-	-
W6S(D)	Screen interval	12-14	0.0/86.9/10.1/3.0	13.1	-	-	-	SM	-	-
W7D	Profile	2-4	0.0/10.5/55.5/34.0	89.5	33	14	-	CL	-	-
W7D(D)	Profile	2-4	0.9/96.9/0.3/1.9	2.2	-	-	-	SP	-	-
W7D	Profile	27-29	1.4/4.1/32.8/61.7	94.5	34	15	-	CL	-	-
B1	Profile	25-27	30.5/62.8/4.3/2.4	6.7	-	-	-	SP-SM	-	-
B1	Profile	31-33	0.7/7.9/43.7/47.7	91.4	31	15	-	CL	-	-
B2A	Profile	15-17	18.3/73.9/5.7/2.1	7.8	-	-	-	SP-SM	-	-
B2	Profile	34-36	7.9/21.1/38.5/32.5	71	23	9	-	CL	-	-
B3	Profile	22-24	18.2/67.6/10.5/3.7	14.2	-	-	-	SM	-	-
B3	Profile	46-48	0.7/11.2/43.3/44.8	88.1	27	12	-	CL	-	-
B4	Profile	37-39	2.3/70.4/23.5/3.8	27.3	-	-	-	SM	-	-
B4(D)	Profile	37-39	1.1/67.7/27.6/3.6	31.2	-	-	-	SM	-	-
B4	Profile	47-49	0.9/7.7/52.3/39.1	91.4	25	11	-	CL	-	-
B5	Profile	29-31	17.3/69.5/8.8/4.4	13.2	-	-	-	SM	-	-
B5	Profile	45-47	0.4/8.5/42.4/48.7	91.1	29	13	-	CL	-	-

Footnotes:

(1) GSA = Grain Size Analysis, % by weight, e.g.,

gravel/sand/silt/clay

5/43/20/32

gravel/sand/silt&clay

26/68/6

(2) P200 = Percent finer than No. 200 sieve, (silt and clay)

(3) LL = Liquid Limit (%)

(4) PI = Plasticity Index

(5) USCS = Unified Soil Classification System

(6) = Total Organic Carbon loss on ignition %

(D) = Duplicate

Notes:

1. -- = Not tested

2. * = Shelby Tube Sample

Table 3-8
Summary of Soil Testing Results
H.O.D. Landfill RI/FS

Boring No.	Sample Depth (ft)	Results of Grain Size Analysis				Hydraulic Conductivity (cm/sec)	Source of Test Results	
		Gravel (%)	Sand (%)	Silt (%)	Clay (%)			
LB1	13.0 to 17.5	46	44	-	10	6.3x10 ^{-3*}	PELA	
LB1	20.5 to 25	33	57	-	10	4.7x10 ^{-4*}	PELA	
LB1	26.5 to 31	52	36	-	12	1.4x10 ^{-3*}	PELA	
LB2	7.0 to 8.5	38	54	-	8	5.0x10 ^{-3**}	PELA	
LB2	11.5 to 13	67	27	-	6	4.1x10 ^{-2**}	PELA	
LB3	5.5 to 7	43	54	-	3	1.2x10 ^{-2**}	PELA	
LB4	10.0 to 11.5	0	92	-	8	5.0x10 ^{-3**}	PELA	
LB4A	22.0 to 23.5	57	41	-	2	4.4x10 ^{-2**}	PELA	
LB4A	38.5 to 40	68	27	-	5	7.3x10 ^{-2**}	PELA	
LB4A	40.0 to 44.5	75	20	-	5	1.4x10 ^{-1**}	PELA	
LB4A	54.5 to 56.5	43	54	-	3	1.4x10 ^{-2**}	PELA	
LB9	8.5 to 11.5	9	72	-	19	7.3x10 ^{-4**}	PELA	
LB9	14.5 to 19	57	35	-	8	1.5x10 ^{-2*}	PELA	
LB9	25.0 to 29.5	52	38	-	10	3.8x10 ^{-4*}	PELA	
LB9	49.0 to 53.5	50	40	-	10	5.9x10 ^{-3**}	PELA	
LB10	10.0 to 14.5	49	46	-	5	1.3x10 ^{-3*}	PELA	
LB10	16.0 to 20.5	45	52	-	3	1.3x10 ^{-3*}	PELA	
LB10	43.0 to 46	47	44	-	9	2.0x10 ^{-2**}	PELA	
LB10	46.0 to 50.5	84	13	-	3	7.7x10 ^{-1**}	PELA	
LB2	18.5 to 19.5	0	27	32	-	41	1.1x10 ^{-8**}	PELA
LB2	64.5 to 65.5	0	47	18	-	35	1.1x10 ^{-8**}	PELA
LB3	16.0 to 17.5	1	25	45	-	29	1.2x10 ^{-8**}	PELA
LB4A	68.5 to 70.5	2	43	31	-	24	1.0x10 ^{-8**}	PELA
GW3I	49.5 to 51	0	10	24	-	66	-	U.S. EPA ESI
GW3I	55.0 to 57.5	0	23	24	-	53	2.3x10 ⁻⁸	U.S. EPA ESI
GW2D	19.0 to 21.5	0	38	44	-	18	1.2x10 ⁻⁶	U.S. EPA ESI
LB10+	56.5 to 58	-	-	-	-	-	1.1x10 ^{-6*}	PELA
LB10+	58.0 to 59.5	-	-	-	-	-	2.9x10 ^{-6*}	PELA
LB10+	59.5 to 61	-	-	-	-	-	6.9x10 ^{-7*}	PELA
LB2	18.5 to 19.5	-	-	-	-	-	1.1x10 ^{-8*}	PELA
LB2	64.5 to 65.5	-	-	-	-	-	1.1x10 ^{-8*}	PELA
LB3	16.0 to 17.5	-	-	-	-	-	1.2x10 ^{-8*}	PELA
LB4A	68.5 to 70.5	-	-	-	-	-	1.0x10 ^{-8*}	PELA
AL384	6.0 (Clay Sample)	-	-	-	-	-	3.4x10 ⁻⁸ (2.7x10 ⁻⁸)	GeoServices
AL385	5.0 (Clay Sample)	-	-	-	-	-	1.9x10 ⁻⁸ (1.6x10 ⁻⁸)	GeoServices
AL386	5.5 (Clay Sample)	0	<1	-	99	-	8.4x10 ⁻⁸ (6.0x10 ⁻⁸)	GeoServices
AL387	10.5 (Clay Sample)	-	-	-	-	-	9.0x10 ⁻⁹ (8.5x10 ⁻⁹)	GeoServices
AL388	6.5 (Clay Sample)	-	-	-	-	-	1.6x10 ⁻⁸ (1.5x10 ⁻⁸)	GeoServices
AL389	8.5 (Silty Sand)	-	-	-	-	-	2.1x10 ⁻⁷ (1.5x10 ⁻⁷)	GeoServices

Notes:

PELA = P.E. LaMoreaux and Associates

ESI = Expanded Site Inspection Report

Where samples have been analyzed for silt plus clay the grain size percentage is shown in the column between silt and clay.

* Samples were disturbed and dehydrated. Results may not be representative.

* Constant Head Permeability

** Permeability estimated by Hazen's Formula

GeoServices = GeoServices, Boynton Beach, Florida. GeoServices results presented in parentheses were obtained using Site leachate as the permeant. Other GeoServices results were obtained using groundwater obtained from the Site.

[chi 609 90b]

TABLE 3-9
Monitoring Well Water Levels
6/8/93-6/9/93
H.O.D. Landfill RI/FS

Well Number	Ground Elevation (ft msl)	TOIC Elevation (ft msl)	Total Depth (ft)	6/8/93 - 6/9/93		9/18/93-9/19/93	
				Groundwater Level (ft)	Groundwater Elevation (ft msl)	Depth to Water from TOIC	Groundwater Elevation
*US1S	766.5	768.69	---	4.3	764.39	6.18	762.51
+US1D	766.9	768.88	ww	38.24	730.64	38.95	729.93
+US2D	768.2	770.73	ww	41.24	729.49	42.19	728.54
*US3S	767.1	770.48	25.4	8.39	762.09	8.88	761.6
-US3I	767.01	769.93	59.95	36.00	733.93	37.5	732.43
+US3D	767.1	769.72	ww	41.31	728.41	40.57	729.15
*US4S	771.1	773.67	ww	11.82	761.85	12.25	761.42
+US4D	770.5	772.7	ww	44.09	728.61	43.4	729.3
+US5D	765.1	767.73	ww	37.55	730.18	38.12	729.61
*US6S	767.1	769.9	---	7.45	762.45	8.2	761.8
-US6I	767.6	770.21	---	32.15	738.06	23.89	746.32
+US6D	767.1	770.09	ww	40.39	729.7	40.45	729.64
-US7S	764.4	767.99	35.95	5.54	762.45	6.95	761.04
+G11S	767.6	770.12	---	4.74	765.38	Dry	Dry
-G11D	767.1	769.99	---	9.31	760.68	9.98	760.01
*G14S	767.6	770.34	ww	5.19	765.15	Dry	Dry
-G14D	767.7	769.75	ww	6.65	763.1	8.12	761.63
*G102	771.1	773.53	ww	11.69	761.84	12.56	760.97
*R103	767.6	769.55	---	7.1	762.45	8.11	761.44
+W2RD	770.7	773.04	88.33	42.3	730.74	43.02	730.02
*W3SA	763.8	766.54	15.64	4.24	762.3	4.9	761.64
*W3SB	763.7	766.81	29.57	4.55	762.26	5.15	761.66
+W3D	763.73	765.93	78	36.66	729.27	35.63	730.3
*W4S	767.5	769.97	15	7.85	762.12	8.34	761.63
*W5S	771.1	773.49	15.36	11.65	761.84	12.07	761.42
*W6S	764.9	767.41	15	4.95	762.46	5.88	761.53
+W7D	780.2	782.87	99.72	52.06	730.81	52.9	729.97
+PZ1	786.2	788.48	119.5	56.84	731.64	57.8	730.68
+PZ2	763	766.44	74.26	29.42	737.02	29A	737.44(A)
*PZ1U	763.9	766.41	27.25	3.47	762.94	4.32A	762.09(A)
*PZ2U	764.1	768.04	19.86	4.89	763.15	5.96	762.08
*PZ3U	763.4	766.27	39.75	3.4	762.87	4.45	761.82
*PZ4U	763.3	766.49	30.35	3.42	763.07	4.53	761.96
*PZ5U	769.3	771.11	34.59	7.49	763.62	8.79	762.32
*PZ6U	763.6	766.54	54.1	3.5	763.04	4.63	761.91

Notes:

- * = Near surface/surficial sand well/water table well
- + = Deep sand and gravel aquifer well
- = Intermediate diameter well
- PZ1 = P.E. Lamoreaux wells
- W6S = Warzyn wells
- G11S/R103 = TSC Wells
- US1S = USEPA Wells
- (ft msl) = Feet above mean sea level
- WW = Total depth measurements were not collected due to Well Wizard installed in well
- = Measurement not collected
- NA = Not applicable
- TOIC = Top of Inner Casing
- (1) = Water levels collected by Wester Gulf Coast Laboratories, Inc.
- (A) = Elevations recorded on September 3, 1993

Elevations surveyed by Gentile and Associates, Inc. for Warzyn on June 28 through July 1, 1993.

Table 3-10

In Situ Hydraulic Conductivity Results
H.O.D. Landfill RI/FS

<u>Well No.</u>	<u>Saturated Test Interval (feet msl)</u>	<u>Saturated Thickness (ft)</u>	<u>Hydraulic Conductivity (cm/sec)</u>	<u>Material Screened (USCS)</u>
W3SB	762 - 734.1	27.9	7.10E-02	SP
W4S	761.9 - 752.5	9.4	9.40E-03	SP-GP
W5S	762.3 - 755.6	6.7	2.90E-03	SM
W3D	*	45	3.80E-04	SP
US1S	764.7 - 754.1	10.6	3.60E-04	GM
US3S	761.8 - 744.6	17.2	2.10E-02	GW-GM
US4S	762.3 - 748.2	14.1	2.30E-02	SW-GW
US6S	762.7 - 725.4	37.3	5.20E-02	SP-GW
US3D	*	45	1.60E-04	SP
US6D	*	45	1.10E-03	SP

Notes:

* - Estimated saturated thickness for confined aquifer of 45 feet
based upon regional data

(msl) = feet above mean sea level

(cm/sec) = centimeters per second

(USCS) = Unified Soil Classification System

Table 3-11

**Summary of Slug Test Analysis
Conducted by U.S. EPA FIT*
H.O.D. Landfill RI/FS**

<u>Well No.</u>	<u>Unit Monitored By Well</u>	<u>Conductivity (cm/sec) (Hvorselv Method)</u>	<u>Transmissivity (T) (ft²/sec) (Cooper Method)</u>	<u>Conductivity (K) (cm/sec) (T = Kb; b = screen length)</u>
US1S	Surficial Sand	4.8x10 ⁻⁴	--	--
US1D	Deep Sand & Gravel	--	3.0x10 ⁻⁴	1.8x10 ⁻³
US2D	Deep Sand & Gravel	--	2.1x10 ⁻³	1.3x10 ⁻²
US3S	Surficial Sand	2.7x10 ⁻²	--	--
US3I	Clay Diamict	7.9x10 ⁻⁶	--	--
US3D	Deep Sand & Gravel	--	5.2x10 ⁻⁴	3.1x10 ⁻³
US4S	Surficial Sand	5.3x10 ⁻²	--	--
US4D	Deep Sand & Gravel	--	1.8x10 ⁻⁴	1.1x10 ⁻³
US5D	Deep Sand & Gravel	--	2.6x10 ⁻³	1.6x10 ⁻²
US6S	Surficial Sand	7.0x10 ⁻²	--	--
US6I	Clay Diamict	8.0x10 ⁻⁶	--	--
US6D	Deep Sand & Gravel	--	3.0x10 ⁻⁴	1.8x10 ⁻³
US7S	Clay Diamict (Sand Lense)	5.8x10 ⁻³	--	--

* Source: Ecology and Environment, Inc. 1989.

TABLE 3-12
Vertical Gradient Calculations
H.O.D. Landfill RI/FS

Well	Position of Head Measurement Elevation (ft MSL)	6/8 - 6/9/93 Water Level Elevation (ft MSL)	Vertical Gradient (ft/ft)
G11D	746.80	760.68	
US5D	684.85	730.18	0.49
US4S	745.00	761.85	
US4D	700.00	729.00	0.73
W3SB	734.16	762.26	
W3D	693.23	729.27	0.81
PZ2U	747.60	763.15	
US2D	684.20	730.74	0.51
W3SA	762.30	762.30	
W3SB	734.13	762.26	0.0014*
US3S	726.50	762.09	
US3D	697.20	728.41	1.15
US6S	715.10	762.45	
US6D	694.30	729.70	1.57
US1S	753.40	764.39	
US1D	691.50	730.64	0.55
US6S	718.10	762.45	
US6I	706.10	738.06	2.03
+US6I	706.10	738.06	
US6D	694.30	729.70	0.71
US3S	726.50	762.09	
+US3I	711.10	733.93	1.83
+US3I	711.10	733.93	
US3D	697.20	728.41	0.40
Notes:			
1. Position of Head Measurement is the elevation of the top of clay and the bottom of clay.			
2. Positive vertical gradients indicate downward flow, negative indicate upward flow.			
3. Vertical Gradient =			
Shallow Well Head Elevation - Deep Well Head Elevation			
Absolute Value of Difference between the elevation of top clay diamict and bottom clay diamict+			
5. (ft MSL) = Feet above Mean Sea Level			
* = Gradient Calculated in Surficial Sand using water table and center of screen elevations			
+ = Center of screen elevation used for intermediate wells.			
SJC/jrs/DAP			
J:10010201/geotable/vertgrad.xls			

TABLE 3-13
Leachate Elevations
H.O.D. Landfill RI/FS

Piezometer Number	Ground Elevation	Depth to Base of Refuse	Landfill Base Elevation	TOIC Elevation	Total Piez. Depth	Depth to Leachate	5/4/93	Leachate Head Above Base	Depth to Leachate	8/20/93 (a)	
							Leachate Elevation			Leachate Elevation	Leachate Head Above Base
LP1	775.6	23.0	752.6	778.46	20.31	12.71	765.75	13.2	11.3	767.19	14.6
LP2	785.5	40.0	745.5	787.8	3.5	20.93	766.87	21.4	18.1	769.8	24.3
LP3	778.1	28.5	749.6	780.89	25.5	15.56	765.33	15.7	16	764.89	15.3
LP4	788.9	40.0	748.9	790.84	39	19.47	771.37	22.5	17.72	773.12	24.2
LP5	796.6	51.0	745.6	800.13	50	40.3	759.83	14.2	38.9	761.23	15.6
LP6	794.6	40.0	754.6	797.32	36.5	20.65	776.67	22.1	17.68	779.64	25.0
LP7	794.7	62.0	732.7	797.39	61	22.75	774.64	41.9	22.8	774.59	41.9
LP8	793.5	70.5	723.0	796.35	70	44.05	752.3	29.3	42.4	753.95	31.0
LP9	785.8	68.5	717.3	789.16	66.5	26.76	762.4	45.1	26.1	763.06	45.8
LP10	781.1	28.5	752.6	783.92	23	19.25	764.67	12.1	17.85	766.07	13.5
LP11	787.8	33.0	754.8	790.61	29.2	20.54	770.07	15.3	19.8	770.81	16.0
LP12	782.6	25.5	757.1	784.85	22.5	20.56	764.29	7.2	19.9	764.95	7.9
LP13	779.0	17.0	762.0	781.68	17	15.46	766.22	4.2	15.13	766.55	4.5
LP14	781.7	23.5	758.2	784.27	22.5	20.2	764.07	5.9	19.43	764.84	6.6
Notes:											
Depths and leachate head are in feet											
Elevations in feet mean sea level											
TOIC = Top of Inner Casing											
Elevations surveyed by Gentile and Associates, Inc. for Warzyn on June 28 through July 1, 1993.											
(a) = Leachate levels collected by Weston Gulf Coast Laboratories, Inc.											

TABLE 4-1
Regulatory Limits
H.O.D. Landfill RI/FS

ANALYSIS TYPE	PARAMETER	Units	U.S.EPA MCL	Illinois Groundwater Quality Standards	
				Class I	Class II
VOC	1,1-Dichloroethane	ug/L			
VOC	1,1-Dichloroethene	ug/L	7	7	35
VOC	1,2-Dichloroethane	ug/L	5	5	25
VOC	1,2-Dichloroethene (cis/trans)	ug/L	70/100	70/100	200/500
VOC	1,2-Dichloropropane	ug/L	5	5	25
VOC	2-Butanone	ug/L			
VOC	2-Hexanone	ug/L			
VOC	4-Methyl-2-pentanone	ug/L			
VOC	Acetone	ug/L			
VOC	Benzene	ug/L	5	5	25
VOC	Carbon disulfide	ug/L			
VOC	Chlorobenzene	ug/L	100	100	500
VOC	Chloroethane	ug/L			
VOC	Chloromethane	ug/L			
VOC	Ethylbenzene	ug/L	700	700	1000
VOC	Methylene chloride	ug/L	5		
VOC	Tetrachloroethene	ug/L	5	5	25
VOC	Toluene	ug/L	1000	1000	2500
VOC	Trichloroethene	ug/L	5	5	25
VOC	Vinyl chloride	ug/L	2	2	10
VOC	Xylenes (total)	ug/L	10000	10000	10000
VOC-Gas	1,2,4-Trimethylbenzene	mg/m3			
VOC-Gas	1,3,5-Trimethylbenzene	mg/m3			
VOC-Gas	4-Ethyl toluene	mg/m3			
VOC-Gas	Trichlorofluoromethane (Freon 11)	mg/m3			
VOC-Gas	Dichlorotetrafluoroethane (Freon 114)	mg/m3			
VOC-Gas	Dichlorodifluoromethane (Freon 12)	mg/m3			
SVOC	1,4-Dichlorobenzene	ug/L	75	75	375
SVOC	2,4-Dimethylphenol	ug/L			
SVOC	2-Methylnaphthalene	ug/L			
SVOC	2-Methylphenol	ug/L			
SVOC	4-Chloroaniline	ug/L			
SVOC	4-Methylphenol	ug/L			
SVOC	Acenaphthene	ug/L			
SVOC	Anthracene	ug/L			
SVOC	Benzo(b)fluoranthene	ug/L	0.2		
SVOC	bis(2-ethylhexyl)phthalate	ug/L	4		
SVOC	Carbazole	ug/L			
SVOC	Dibenzofuran	ug/L			
SVOC	Diethylphthalate	ug/L			
SVOC	Fluoranthene	ug/L			
SVOC	Fluorene	ug/L			
SVOC	Naphthalene	ug/L			
SVOC	Phenanthrene	ug/L			
SVOC	Phenol	ug/L		100	100
SVOC	Pyrene	ug/L			
PPCB	4,4'-DDD	ug/L			
PPCB	Aroclor-1016	ug/L	0.5	5	2.5

TABLE 4-1
Regulatory Limits
H.O.D. Landfill RI/FS

ANALYSIS		Units	U.S.EPA MCL	Illinois Groundwater Quality Standards	
TYPE	PARAMETER			Class I	Class II
MTL	Aluminum	ug/L	50		
MTL	Arsenic	ug/L	50	50	200
MTL	Barium	ug/L	2000	2000	2000
MTL	Beryllium	ug/L	1		
MTL	Cadmium	ug/L	5	5	50
MTL	Calcium	ug/L			
MTL	Chromium, total	ug/L	100	100	1000
MTL	Cobalt	ug/L		1000	1000
MTL	Copper	ug/L	1000	650	650
MTL	Cyanide, Total	ug/L	200	200	600
MTL	Iron	ug/L	300	5000	5000
MTL	Lead	ug/L	15	7.5	100
MTL	Magnesium	ug/L			
MTL	Manganese	ug/L	50	150	10000
MTL	Mercury	ug/L	2	2	10
MTL	Nickel	ug/L	100	100	2000
MTL	Potassium	ug/L			
MTL	Silver	ug/L	100	50	
MTL	Sodium	ug/L			
MTL	Thallium	ug/L	2		
MTL	Vanadium	ug/L			
MTL	Zinc	ug/L	5000	5000	10000
IND	Alkalinity, Total	mg/L			
IND	Chloride	mg/L	250	200	200
IND	Hardness	mg/L			
IND	Nitrate Nitrogen	mg/L	10	10	100
IND	Nitrite Nitrogen	mg/L			
IND	Nitrogen, Ammonia	mg/L			
IND	Sulfate	mg/L	250	400	400
IND	Total Dissolved Solids	mg/L	500	1200	1200
IND	Total Organic Carbon	mg/L			
IND	pH	SI		6.5 - 9.0	6.5 - 9.0

This table presents regulatory limits for all compounds detected at the HOD Landfill RI/FS Site.

1. MCL is the U.S.EPA Maximum Contaminant Level.
2. Class I is the Illinois EPA Groundwater Quality Standard for Potable Resource Groundwaters.
3. Class II is the Illinois EPA Groundwater Quality Standard for Potable Resource Groundwaters.

Revised 8/27/93

[J:10010201:REGLIST.XLS/JAH/]

TABLE 4-2
Summary Of Background Metals and Indicator Results
H.O.D. Landfill RI/FS

Parameter	Samples Analyzed	Minimum	Maximum	Average	Standard Deviation	Background Value	Database Description
Dissolved Metals							
Arsenic	23	0.5	10	2.09	2.44	6.97	ARSENIC, DISSOLVED (UG/L AS AS)
Barium	30	25	100	70.6	23.5	118	BARIUM, DISSOLVED (UG/L AS BA)
Cadmium	22	0.5	3	1.45	0.53	2.52	CADMIUM, DISSOLVED (UG/L AS CD)
Calcium	56	3,000	76,000	35,245	13,480	62,205	CALCIUM, DISSOLVED (UG/L AS CA)
Copper	25	1.5	71	6.30	14.15	34.6	COPPER, DISSOLVED (UG/L AS CU)
Lead	22	2.5	26	6.98	6.81	20.59	LEAD, DISSOLVED (UG/L AS PB)
Magnesium	56	2,300	75,700	29,846	12,115	54,076	MAGNESIUM, DISSOLVED (UG/L AS MG)
Mercury	21	25	150	41.2	38.5	118	MERCURY, DISSOLVED (UG/L AS HG)
Nickel	23	1.0	100	8.87	20.6	50.10	NICKEL, DISSOLVED (UG/L AS NI)
Potassium	34	910	5,100	1,624	650	2,923	POTASSIUM, DISSOLVED (UG/L AS K)
Selenium	22	0.50	1.00	0.52	0.11	0.74	SELENIUM, DISSOLVED (UG/L AS SE)
Silver	22	2.50	10	2.84	1.60	6.04	SILVER, DISSOLVED (UG/L AS AG)
Sodium	58	9,000	83,000	42,205	13,411	69,028	SODIUM, DISSOLVED (UG/L AS NA)
Zinc	23	1.00	212	14.3	43.9	102	ZINC, DISSOLVED (UG/L AS ZN)
Total Metals							
Aluminum	18	25	1,364	99.4	315.61	731	ALUMINUM, TOTAL (UG/L AS AL)
Arsenic	18	0.50	26	2.62	5.95	14.5	ARSENIC, TOTAL (UG/L AS AS)
Barium	18	35	182	63.8	32.3	128	BARIUM, TOTAL (UG/L AS BA)
Beryllium	34	0.25	1.00	0.45	0.24	0.92	BERYLLIUM, TOTAL (UG/L AS BE)
Boron	18	228	419	339	56.04	451	BORON, TOTAL (UG/L AS B)
Cadmium	18	1.50	1.50	1.50	0	1.50	CADMIUM, TOTAL (UG/L AS CD)
Calcium	18	29,000	73,000	38,889	11,245	61,380	CALCIUM, TOTAL (UG/L AS CA)
Chromium	40	2.50	10	2.69	1.19	5.06	CHROMIUM, TOTAL (UG/L AS CR)
Cobalt	37	2.50	9.00	2.96	1.46	5.89	COBALT, TOTAL (UG/L AS CO)
Copper	18	2.50	9.00	2.86	1.53	5.93	COPPER, TOTAL (UG/L AS CU)
Iron	55	100	620	380	158	697	IRON, TOTAL (UG/L AS FE)
Lead	17	2.50	8.00	2.97	1.43	5.83	LEAD, TOTAL (UG/L AS PB)
Magnesium	18	25,000.00	41,000	31,056	5,047	41,149	MAGNESIUM, TOTAL (UG/L AS MG)
Manganese	28	5.00	16	9.50	3.04	15.6	MANGANESE, TOTAL (UG/L AS MN)
Mercury	18	0.01	0.06	0.03	0.02	0.07	MERCURY, TOTAL (UG/L AS HG)
Nickel	18	2.50	14.00	3.72	2.89	9.50	NICKEL, TOTAL (UG/L AS NI)
Potassium	18	0.15	2,400	1,272	677	2,626	POTASSIUM, TOTAL (UG/L AS K)
Selenium	18	0.50	2.50	0.64	0.48	1.60	SELENIUM, TOTAL (UG/L AS SE)
Silver	18	1.50	5.00	1.89	0.99	3.88	SILVER, TOTAL (UG/L AS AG)
Sodium	18	23,000	62,000	43,500	8,767	61,033	SODIUM, TOTAL (UG/L AS NA)
Vanadium	34	2.00	5.00	2.35	0.53	3.41	VANADIUM, TOTAL (UG/L AS V)
Zinc	18	25	50	26.39	5.89	38.2	ZINC, TOTAL (UG/L AS ZN)
Indicators							
Alkalinity	58	4	254	214	40.85	296	ALKALINITY, TITRATION TO PH 4.5 (MG/L AS CaCO3)
Chloride diss.	58	1	7	3.19	1.69	6.57	CHLORIDE, DISSOLVED (MG/L AS CL)
Hardness	58	18	296	189	68.88	327	HARDNESS, TOTAL (MG/L AS CaCO3)
Ammonia	18	0.30	5	0.72	1.01	2.74	NITROGEN, AMMONIA TOTAL (MG/L AS N)
Nitrate, dis.	21	0.05	1	0.47	0.28	1.03	NITROGEN, NITRATE, DISSOLVED (MG/L AS N)
NO2 - NO3	39	0.05	1	0.08	0.17	0.42	NITROGEN, NITRITE PLUS NITRATE, TOTAL (MG/L AS N)
Sulfate diss.	57	2	72	52.0	16.7	85.5	SULFATE, DISSOLVED (MG/L AS SO4)

This table presents a statistical summary of metal and indicator results from the Illinois State Water Survey's Ground-water Quality Database for Township 46N, Range 10E, (all Sections), of Lake County, Illinois. 98 samples (out of a total of 1917 samples for the county) were found in the database for the specified location. The number of samples specified is the number analyzed for that parameter. Minimum, maximum, and average values are presented. Background values, used for comparison to H.O.D. site sample results, are calculated as the average plus two times the standard deviation of all reported detects. If a constituent was not reported at the detection limit, a value equal to one-half the reported detection limit was used for statistical analysis. Total metals results are compared to private well sample data (which are not filtered), and dissolved metals results are compared to groundwater monitoring well data (which are filtered).

Revision: 8/31/93

[chux://mnt/chux/jobs/10010201/technical/background/bkd-Tbl.xls/JAH/AJS]

TABLE 4-3
Summary of Landfill Gas Results
H.O.D. Landfill RI/FS

Compound	Molecular Weight	HD-1-G1-P01-91	HD-1-G1-P06-01	HD-1-G1-P07-01	HD-1-G1-P08-01	HD-1-G1-P11-01	HD-1-G1-P11-91
1,1-Dichloroethane	99		570	2,200			
1,1-Dichloroethene	97			1,900			
1,2,4-Trimethylbenzene	181		3,300	8,900	16,000		3,100
1,3,5-Trimethylbenzene	181		1,500	3,800	6,700		
2-Butanone	72	62	5,300	15,000	65,000		1,800
4-Ethyl toluene	120		2,600	6,400	13,000		2,400
Acetone	58		1,700	9,300	36,000		
Benzene	78	32	1,300	3,100	2,100	2,010	2,200
Carbon disulfide	76		2,100				
Chlorobenzene	113		830		21,000		
Chloroethane	65	120	2,200				
Chloromethane	50				1,500		
cis-1,2-Dichloroethene	97	25	1,500	21,000	5,600	9,500	11,000
Ethylbenzene	106	150	16,000	48,000	42,000	14,000	15,000
Trichlorofluoromethane (Freon 11)	137	440	67,000	1,500		1,700	18,000
Dichlorotetrafluoroethane (Freon 114)	171		50,000		5,300	6,000	6,600
Dichlorodifluoromethane (Freon 12)	121		31,000	8,900	10,000	45,000	43,000
Methylene chloride	85	330	760				1,800
Tetrachloroethene	166		1,800	30,000	5,600	18,000	19,000
Toluene	92	2,000	41,000	250,000	200,000	75,000	79,000
Trichloroethene	131		860	13,000	3,200	5,100	5,400
Vinyl chloride	63		13,000	54,000	33,000	2,800	3,400
Xylenes (total)	106	220	33,000	130,000	100,000	30,000	31,000

Notes:

1. This table presents all volatile compounds detected in landfill gas samples collected from landfill gas wells at HOD Landfill during May 1993.

2. Sample results are in mg/m³. These values were calculated from units of parts per billion, volume to volume (ppb(v/v)), as reported in the complete analytical reports included in the Appendices. The conversion to mg/m³ is as follows:

$$\text{mg/m}^3 = (\text{ppb(v/v)} * \text{MW}) / 24.45 \text{ Liters}$$

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version 8/26/93

TABLE 4-4
Summary of Volatile Organics Compounds in Groundwater, Surface Water, Surface Soils, and Leachate
H.O. D. Landfill RI/FS

SAMPLE ID	Alkenes					Alkanes			Ketones				Aromatics						
	Tetrahydroethene	Trichloroethene	1,1-Dichloroethene	1,2-Dichloroethene (total)	Vinyl chloride	1,1-Dichloroethane	1,2-Dichloroethane	Chloroethane	1,2-Dichloropropane	4-Methyl-2-pentanone	2-Butanone	2-Hexanone	Acetone	Benzene	Ethylbenzene	Toluene	Xylene (total)	Carbon disulfide	Methylene chloride
MCL	5	5	7	70	2		5		5					5	700	1,000	1,000		5
Class I	5	5	7	70	2		5							5	700	1,000	1,000		
Class II	25	25	35	200	10		25							25	1,000	2,500	1,000		
Groundwater - Shallow On-Site																			
HD-GWG11S-01																			8
HD-GWUS04S-01				35															
HD-GWUS061-01		2																	
HD-GWUS06S-01																			
HD-GWUS06S-01																			
HD-GWUS06S-01					19														
HD-GWW06S-01				2															
Groundwater - Shallow Off-Site																			
HD-GWUS01S-01																			
HD-GWUS03E-01																			
HD-GWUS03S-01																			
HD-GWW03SB-01																			
HD-GWW04S-01																			
HD-GWW04S-01																			
Groundwater - Deep On-Site																			
HD-GWG11D-01																			
HD-GWUS04D-01																			
HD-GWUS04D-01																			
HD-GWUS06D-01																			
HD-GWW07D-01																			
Groundwater - Deep Off-Site																			
HD-GWUS01D-01																			
HD-GWUS03D-01				11	28														
HD-GWW03D-01																			
Surface Water																			
HD-SWS101-01																			
HD-SWS201-01																			
HD-SWS301-01									2		3								
HD-SWS301-01																			
Surface Soils																			
HD-SUC1-01													140	7	240	55	280		57
HD-SUC2-01													17		12	3	37	6	60
HD-SUC3-01													8						24
HD-SUC4-01																			12
HD-SUC4-01													15			2			27
HD-SUC5-01																			
Leachate																			
HD-LCLP01-01	9			7				45	22	190	14	110		12	52	330	100		10
HD-LCLP01-01								46	22					13	46	480	90		10
HD-LCLP06-01									160	3,200		2,200				210	170		10
HD-LCLP08-01									450	12,000		19,000				260			
HD-LCLP11-01				190						3,900		1,500			130	740	330		
HD-LCMHE-01	9	14	5	70	18	13	22		28	43	120		140	22		62	41		40

Notes:

1. This table presents volatile organic compounds detected in samples collected during May 1993.
2. Results are in parts per billion (ppb), ug/L for groundwaters, surface waters, and leachates, and ug/kg for soils.
3. MCLs are U.S. EPA Maximum Contaminant Limits for groundwater. Class I and Class II are IEPA Groundwater Quality Standards. Class I (potable resource) applies to deep sand and gravel aquifer groundwater, Class II (general resource) applies to surficial sand and clay diameter groundwater. Bolded groundwater results exceed the MCL.

Revised 9/16/93

[F:\0010201 VOC XLS\AH:AJ5]

TABLE 4-5
SUMMARY OF HISTORICAL MONITORING WELL VOC DATA
H.O.D. Landfill RI/FS

SAMPLE ID	Date	Trichloroethene	1,2-Dichloroethene (cis/trans)	Vinyl chloride	4-Methyl-2-pentanone	Acetone	Methylene chloride	Benzene	Toluene
US01D	11/8/87					22.9	34.5		
US01S	8/11/87					26.3	9.47		
US03D	5/8/90			12.3					
US03S	8/11/87				13.9	26	9.37		
US04D	8/10/87					19.2	5.7		
US04S	8/10/87		76.4			21.5			
	4/18/88		69			3			
	5/9/90		41.1						
	7/26/90		41.5						
US06D	5/19/88	0.47					4.2		
	5/19/88	0.66					4		
	5/9/90	0.5							
	7/26/90	0.7							
US06I	8/12/87	8.69				21.2	6.59		
	4/18/88	5				4	2		
	5/19/88	5.3	1.2				1.1		
	8/18/88	5				5	2		2
US07S	8/11/87				4	21.3	9.6	12.8	
G102	4/19/88								2
	5/10/90			2.4					

Notes:

1. This table presents historical data for H.O.D Landfill for monitoring wells. Only wells and sampling rounds with VOC detects are presented in this table. Acetone and methylene chloride are often lab contaminants. Warzyn did not perform data validation for the sampling rounds and has not assessed data quality.

2. All results are in units of ug/L.

Revised 8/27/93

[J:10010201:GW-HIS.XLS/JAH/AJS]

TABLE 4-6
Summary of Semivolatile Organic Compounds in
Groundwater, Surface Water, Surface Soils, and Leachate
H.O.D. Landfill RI/FS

	Phenols				Phthalates	Polynuclear Aromatic Hydrocarbons											Pest.PCPs			
SAMPLE ID	Phenol	2,4-Dimethylphenol	2-Methylphenol	4-Methylphenol	Diethylphthalate	bis(2-ethylhexyl)phthalate	Acenaphthene	Anthracene	Benzo(b)fluoranthene	Carbazole	Dibenzofuran	Fluoranthene	Fluorene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Pyrene	1,4-Dichlorobenzene	4,4'-DDD	Aroclor-1016
MCL						4			0.2									75		0.5
Class I	100																	75		0.5
Class II	100																	375		2.5
Groundwater - Shallow On-Site																				
HD-GWG11S-01																				
HD-GWUS04S-01																				
HD-GWUS06I-01																				
HD-GWUS06S-01																				
HD-GWUS06S-91																				
HD-GWW05S-01																				
HD-GWW06S-01																				
Groundwater - Deep On-Site																				
HD-GWG11D-01																				
HD-GWUS04D-01																				
HD-GWUS04D-91																				
HD-GWUS06D-01																				
HD-GWW07D-01																				
Groundwater - Shallow Off-Site																				
HD-GWUS01S-01																				
HD-GWUS03I-01																				
HD-GWUS03S-01																				
HD-GWW03SB-01																				
HD-GWW04S-01																				
HD-GWW04S-91																				
Groundwater - Deep Off-Site																				
HD-GWUS01D-01																				
HD-GWUS03D-01																				
HD-GWW03D-01																				
Surface Soils																				
HD-SU01-01						160	120	46	130	59	110	68	61	320	250	77	130	4.3		
HD-SU02-01						320	1,000			620		500	390	630	240					
HD-SU03-01						280		110			160				120	110				
HD-SU04-01						3,500					59				36	52				
HD-SU04-91						3,600														
HD-SU05-01						9,600					73				51	54				
Surface Water																				
HD-SWS101-01																				
HD-SWS201-01																				
HD-SWS301-01																				
HD-SWS301-91																				
Leachate																				
HD-LCLP01-01	160	12		730	32															4.6
HD-LCLP01-91	170	11		760	31										34					6.3
HD-LCLP06-01	83	4	16	1,300											6			5		
HD-LCLP08-01	840	20		2,200											26					
HD-LCLP11-01	5	3		48	4	42									16					
HD-LCMHE-01	19	6		5														20		

Notes:

1. This table presents semivolatile organic compounds detected in samples collected from HOD Landfill during May 1993.

2. Results are in parts per billion (ppb); ug/L for groundwaters, surface waters, and leachates, and ug/kg for soils.

3. MCLs are U.S. EPA Maximum Contaminant Levels for groundwaters. Class I and Class II are EPA Groundwater Quality Standards. Class I (potable water resource) is applicable to the deep sand and gravel aquifer groundwater, and Class II (general resource groundwater) is applicable to the surficial sand and clay diamict groundwater. Bolded values exceed the MCL.

TABLE 4-7
Summary Of Metals In Groundwater, Surface Water, Surface Soils, and Leachate
H.O.D. Landfill RI/FS

Sample ID	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium, total	Cobalt	Copper	Cyanide	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Silver	Sodium	Thallium	Vanadium	Zinc
MCL	50	5	50	2,000	1	5		100		1,000	200	300	15		50	2	100		100		2		5,000
Class I			50	2,000		5		100	1,000	650	200	5,000	7.5		150	2	100		50				5,000
Class II			200	2,000		50		1,000	1,000	650	600	5,000	100		10,000	10	2,000						10,000
Background Value			6.97	118		2.52	62,200			34.6			20.6	54,100		118	50.1	2,920	6.04	69,000			102
Groundwater Shallow On-Site																							
HD-GWUS04S-01				106			119,000					2,700		46,700	72.7		9.7	1,570		55,800			
HD-GWUS06I-01			9.5	53.6			51,200							43,900	20.3			17,600		33,900			
HD-GWUS06S-01				68.1			105,000					2,530		44,800	87.7			1,290		17,500			
HD-GWUS06S-91				66.7			105,000					3,200		43,400	84.9			1,200		16,800			
HD-GWW05S-01				182			148,000					2,480		40,200	692			4,250		38,900			
HD-GWW06S-01				116			353,000	4.4				3,600		126,000	745			4,620		24,300			
Groundwater Shallow Off-Site																							
HD-GWUS01S-01				34.9			83,700			4.4		805		39,200	261					21,300			
HD-GWUS03I-01			6.3	41.1			45,500							34,000	39.6					40,200			
HD-GWUS03S-01				55.1			79,800					1,230		29,600	50.1			2,990		98,500			
HD-GWW03SB-01				95.3			128,000					1,070		55,000	109		6.0	1,750		64,500			552
HD-GWW04S-01				363			163,000	4.4	9.0			238		42,500	1,070		8.4	14,000		50,900			248
HD-GWW04S-91			4.1	354			155,000		4.1			206		42,400	1,110			14,100		52,500			333
Groundwater Deep On-Site																							
HD-GWG11D-01			3.1	282		5.6	112,000	3.5						98,600	32.0			3,050		33,700	2.1		
HD-GWUS04D-01				47.6			40,300							26,500	18.0			1,810		50,300			
HD-GWUS04D-91				59.1			43,200					225		25,300	16.0			1,400		38,100			
HD-GWUS06D-01				69.0			48,200					845		24,400	31.0			1,820		49,500			
HD-GWW07D-01				73.8			36,500							21,800	53.4			1,580		52,300			
Groundwater Deep Off-Site																							
HD-GWUS01D-01				89.8			58,800					660		41,700	58.7			1,150		25,400			
HD-GWUS03D-01				129			96,500					2,400		46,200	42.4			2,580		67,500			474
HD-GWW03D-01				163			115,000	4.3				707		62,500	141		5.2	2,610		63,200			514
Surface waters																							
HD-SWS101-01	113			19.4		3.3	52,600	3.2		2.3				25,700	50.9			2,210		26,000			
HD-SWS201-01	107			22.2			46,700			2.1		424		24,900	56.8			2,110		34,400			
HD-SWS301-01	55.5			21.9			52,500					318	2.0	25,500	54.2			2,060		35,600			
HD-SWS301-91	91.1	27.6		22.2			52,400					355		25,400	53.7			2,010		34,900			
HD-SWFB01-01							1,260					35.2		25.6									154

TABLE 4-7
Summary Of Metals In Groundwater, Surface Water, Surface Soils, and Leachate
H.O.D. Landfill RI/FS

Sample ID	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium, total	Cobalt	Copper	Cyanide	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Silver	Sodium	Thallium	Vanadium	Zinc
Leachate																							
HD-LCLP01-01	57,100		31.3	510	4.0	21.3	448,000	126	52.8	207.0		154,000	241	357,000	2,260	0.43	184	283,000	3.0	1,080,000	2.0	114	
HD-LCLP01-91	222,000		32.0	1,710	12.5	67.9	1,410,000	418	185.0	755.0		612,000	884	780,000	9,020	1.8	560	297,000	10.9	1,030,000		686	5,280
HD-LCLP06-01	4,770		30.6	257	1.2	5.8	204,000	42.1	14.3	33.7		24,800	79.8	282,000	816		76.0	507,000		1,140,000		20.3	66
HD-LCLP08-01	18,000		39.3	459	1.4	5.6	119,000	68.0	38.9	63.7		43,000	104	211,000	676	1.3	203	495,000		1,530,000	2.2	45.2	
HD-LCLP11-01	65,900		51.3	1,610	4.9	35.4	550,000	174	49.9	378.0	37.8	257,000	1,930	333,000	2,700	1.3	172	82,000	8.2	268,000		105	
HD-LCMHE-01	151		4.1	636			90,300	9.9	8.1	9.4		7,900	6.2	138,000	76.2		21.9	113,000		480,000	2.0	2.4	
HD-LCFB01-01	62.2						6,190			5.2		22.6		32.9	2.7					726			600
Surface Soils																							
HD-SU01-01	7,450		5.2	32.5	0.66		78,500	14.3	8.6	19.6		17,600	12.7	41,000	418		19.2	1,940		524	0.6	18.6	45.4
HD-SU02-01	6,260		1.9	25.1	0.55		88,200	10.4	4.1	17.6		9,160	11.5	31,000	88.6		10.5	1,270		133		15.1	46.2
HD-SU03-01	6,640		4.1	30.7	0.54	1.0	62,900	12.5	6.2	19.0		23,500	12.4	31,500	367		15.2	1,720		155		19.4	48.2
HD-SU04-01	8,740		2.2	50.0	0.50		22,400	15.6	8.6	15.1		17,500	10.5	11,000	502		15.8	1,200		64		26.0	43.0
HD-SU04-91	8,740		3.3	57.0	0.55		21,300	15.4	13.4	15.2		18,200	13.4	11,500	984		16.1	1,230		68		27.8	43.8
HD-SU05-01	8,450		4.4	40.4	0.74	1.3	79,100	16.1	10.8	25.8		22,100	13.7	40,800	623		23.0	1,760		175	0.8	24.6	74.8
Regional Range	7000 -100000	<1.88	<0.173	10-1500	<1.7		100-200000	1-1000	<0.370	<1700		100->100000	<10-300	50-500000	<27000	0.01-4.1	<5700	500-12000		500-50000	2-22.3	<1.000	<5,280
Common Range	10000-300000	1-50	1-50	100-3000	0.1-40	0.01-0.70	7000-500000	1-1000	1-40	2-100		7000-550000	2-200	600-6000	20-1000	0.01-0.3	5-500	500-10000	0.01-5	750-7500	20-500	10-500	

Notes

1. This table presents all metals detected in samples collected from HOD Landfill during May 1993. Results are in ug/l. for groundwater, surface water, and leachate, and mg/kg for soils.
2. MCLs are U.S. EPA Maximum Contaminant Levels for groundwaters. Class I and Class II are BEPA Groundwater Quality Standards. Class I (potable water resource) is applicable to the deep sand and gravel aquifer groundwater, and Class II (general resource groundwaters) is applicable to surficial sand and clay dune groundwater. Bolded values exceed the MCL.
3. Well G11S was not sampled for metals analysis because sufficient sample volume could not be collected.
4. Background metal concentrations for local soils were unavailable. In order to provide a means of comparing the soil metal concentrations onsite, observed concentration ranges for soils are presented from two sources. The Regional range (i.e., Eastern United States) were obtained from "Element Concentrations in Soils and other Surficial Materials of the Conterminous United States, U.S. Geological Survey Paper 1270, 1984. The common ranges were obtained from Table 1-1 The Content of Various Elements in the Lithosphere and in Soils, of "Chemical Equilibria in Soils" by Willard L. Lindsay.

Revised 9/17/93
 [J:10010201:MTL.XLS/JAH/AJS]

TABLE 4-8
Summary of Groundwater/Leachate Quality Indicator Results
H.O.D. Landfill RI/FS

SAMPLE ID	Nitrogen, Ammonia	Nitrogen, Nitrate	Nitrogen, Nitrite	Carbon, Total Organic	Sulfate	Hardness	Alkalinity, Total	Chloride	Total Dissolved Solids
SMCL		10			250			250	500
Class I		10			400			200	1,200
Class II		100			400			200	1,200
Background Value	2.74	1.03			85.5	327	296	6.57	
Groundwater - Shallow On-Site									
HD-GWUS04S-01		0.02		3.1	133	514	367	93	620
HD-GWUS06I-01	0.28			2.3	32	416	328	27	516
HD-GWUS06S-01		0.05		5.1	31	630	398	44	304
HD-GWUS06S-91		0.04		5.4	31	551	399	43	600
HD-GWW05S-01	3.73	0.05		7.7	49	798	518	59	372
HD-GWW06S-01	0.78	0.06		8.4	790	1,800	640	49	392
Groundwater Shallow - Off-Site									
HD-GWUS01S-01		0.04		1.2	39	561	310	55	412
HD-GWUS03I-01		0.04			30	900	303	8	506
HD-GWUS03S-01	1.02	0.14		5.9	40	1,140	380	104	448
HD-GWW03SB-01				2.5	171	614	390	103	344
HD-GWW04S-01	14.5			13.0		1,290	580	102	344
HD-GWW04S-91	22.8			10.0		1,200	572	101	666
Groundwater - Deep On-Site									
HD-GWUS04D-01	0.79				67	216	225	3	744
HD-GWUS04D-91	0.74			1.2	68	222	227	3	756
HD-GWUS06D-01	0.75			5.5	90	227	218	8	664
HD-GWW07D-01	0.71				124	261	181	4	380
Groundwater - Deep Off-Site									
HD-GWUS01D-01	0.77			1.3	49	346	318	22	788
HD-GWUS03D-01		0.03			49	620	358	144	834
HD-GWW03D-01				1.3	95	574	393	153	1,880
Leachate									
HD-LCLP01-01	214	0.06	0.03	32.5	74	3,460	2,720	1,310	4,490
HD-LCLP01-91	223		0.05	30.5	74	1,070	2,660	1,330	10,200
HD-LCLP06-01	327		0.19	36.5	28	1,660	4,360	1,270	5,820
HD-LCLP08-01	378		0.14	36.0	17	1,150	3,490	2,070	6,560
HD-LCLP11-01	45	0.02	0.07	120.0	530	1,730	1,780	196	2,570
HD-LCMHE-01	106	0.05		110.0	57	768	1,700	823	2,430

Notes:

- 1) This table presents groundwater quality indicator parameter results for H.O.D. Landfill groundwater and leachate samples collected in May 1993.
- 2) Results are in mg/L.
- 3) SMCLs are U.S. EPA Secondary Maximum Contaminant Levels. Class I and Class II are IEPA Groundwater Quality Standards. Class I (potable resource groundwater) applies to the deep sand and gravel aquifer groundwater, and Class II (general resource groundwater) applies to the surficial sand and clay diamicton groundwater. Bolded values exceed the SMCL.
- 4) Well G11S and G11D were not sampled for indicator parameters because sufficient sample volume could not be collected.

Revised 8/26/93

[J:10010201:IND.XLS/JAH/AJS]

TABLE 4-9
Summary of Chemical Constituents Detected at
Village of Antioch Water Supply Wells and Private Residence Wells
H.O.D. Landfill RI/FS

Parameter	MCL	Class I	Background Value	HD-VW03-01	HD-VW05-01	HD-VW05-91	HD-PW01-01	HD-PW02-01	HD-PW03-01	HD-PW05-01
Volatiles										
Carbon disulfide					0.6	0.6				
Semivolatiles										
2-Methylphenol					0.5			0.9		
4-Chloroaniline				0.7						
Metals										
Aluminum	50		731		55				75	
Arsenic	50	50	14.5	2.1	4	4.5				
Barium	2,000	2,000	128	59	94	88	260	109	131	61
Calcium			61,400	41,000	55,400	54,400	82,700	31,900	32,700	25,600
Chromium, total	100	100	5.06		0.25	0.24	0.89	0.56	0.2	0.46
Cobalt		1,000	5.89					10		
Copper	1,000	650	5.93				26			
Iron	300	5,000	697	646	1,100	1,100	3,050	643	549	162
Lead	15	8	5.83				5.5			
Magnesium			41,100	29,800	36,600	37,400	47,600	14,900	14,500	17,200
Manganese	50	150	15.6		10	10	26			
Potassium			2,630	1,490	1,590	1,570	2,320	1,570	1,760	1,060
Sodium			61,000	41,300	27,800	30,200	56,400	53,000	53,400	60,600
Vanadium			3.41				2.7			
Zinc	5,000	5,000	38.20	25			73		608	48

1. This table presents all compounds and inorganic analytes detected in private well (PW) and village well (VW) samples collected in the vicinity of H.O.D. Landfill during June and July, 1993.
2. All results are in ug/L.
3. MCLs are U.S.EPA Maximum Contaminant Levels. Class I are IEPA Groundwater Quality Standards for potable resource groundwaters. Bolded values exceed the MCL. Background values are calculated as the mean plus two times the standard deviation of data provided by the State of Illinois.

Revised 8/26/93

[J:10010201:PW.XLS/JAH/AJS]

TABLE 4-10
Summary of VOCs Detected In
Village Well No. 4 Finished Water
H.O.D. Landfill RI/FS

Date	cis-1,2-Dichloroethene	Chloromethane	Chloroform
7-Jan-92	0.5	<	<
7-Apr-92	<	<	0.9
4-Jun-92	<	<	<
6-Jul-92	<	2.2	<
3-Aug-92	<	<	<
4-Aug-92	<	<	<
16-Sep-92	0.5	<	<
21-Oct-92	<	<	<
3-Nov-92	0.8	1.3	<
11-Jan-93	<	<	<
8-Feb-93	<	<	<
1-Mar-93	0.6	<	<
6-Apr-93	<	<	<
4-May-93	<	<	<

Notes:

1. This table presents all reported detects of volatile organic compounds in water samples collected from Village Well No. 4 finished water which presumably is chlorinated.
2. Sampling was conducted by the Village of Antioch.
3. Results are in ug/L.
4. - = Not analyzed
5. ND = not detected <Not detected at detection limits.
6. For 1992 and 1993 data, detection limits are 0.2 for trichloroethene, 0.5 ug/L for vinyl chloride, trans- and cis-1,2-dichloroethene, and 1.0 ug/L for chloromethane and chloroform.
7. The compounds chloromethane and chloroform can be produced during chlorination of groundwater and may not be related to an external contaminant source.

Revised 8/31/93

[J:10010201:VW4-HIS.XLS/JAH/AJS]

TABLE 5-1
Summary of Physical and Chemical Properties of Compounds Detected at H.O.D. Landfill
H.O.D. Landfill RI/FS

COMPOUND	Molecular Weight (g/mole)	Water Solubility (mg/L)	Density (g/cc)	Henry's Law Constant (atm-m ³ /mole)	Koc (ml/g)	Log Kow (ml/g)	Vapor Pressure (mm Hg)	Retardation Factor
Volatile Organic Compounds								
Chloromethane	50	6.50E+03	0.92	4.40E-02	35	0.95	4.31E+03	1.2
Vinyl chloride	63	2.67E+03	1.37	8.19E-02	57	1.38	2.66E+03	1.3
Chloroethane	65	3.33E+03	0.92	1.16E-02	50	1.54	4.57E+02	1.3
Methylene chloride	85	2.00E+04	1.33	2.03E-03	8.8	1.30	3.60E+02	1.1
Acetone	58	1.00E+06	0.79	2.06E-05	2.2	-0.24	2.70E+02	1.0
Carbon disulfide	76	2.94E+03	1.26	1.23E-02	54	2.00	3.60E+02	1.3
1,1-Dichloroethene	97	2.25E+03	1.22	3.40E-02	65	1.84	6.00E+02	1.4
1,1-Dichloroethane	99	5.50E+03	1.18	4.31E-03	30	1.79	1.82E+02	1.2
1,2-Dichloroethene	97	6.30E+03	1.26	6.56E-03	39	0.48	3.24E+02	1.2
1,2-Dichloroethane	99	8.52E+03	1.25	9.78E-04	14	1.48	6.40E+01	1.1
2-Butanone	72	2.68E+05	0.81	2.74E-05	4.5	0.26	7.75E+01	1.0
1,2-Dichloropropane	113	2.70E+03	1.16	2.31E-03	51	2.00	4.20E+01	1.3
Trichloroethene	131	1.10E+03	1.46	9.10E-03	126	2.38	5.79E+01	1.8
Benzene	78	1.75E+03	0.88	5.59E-03	83	2.12	9.52E+01	1.5
4-Methyl-2-pentanone	100	1.70E+04	0.8	1.59E-02	20.5	0.88	6.00E+00	1.1
2-Hexanone	102	3.50E+04	0.83	7.67E-06	14	1.38	2.00E+00	1.1
Tetrachloroethene	166	1.50E+02	1.62	2.59E-02	364	2.60	1.78E+01	3.2
Toluene	92	5.35E+02	0.87	6.37E-03	300	2.73	2.81E+01	2.8
Chlorobenzene	113	4.66E+02	1.11	3.72E-03	330	2.84	1.17E+01	3.0
Ethylbenzene	106	1.52E+02	0.87	6.43E-03	1100	3.15	7.00E+00	7.6
Total Xylenes	106	4.66E+02	0.9	7.04E-03	330	3.26	1.00E+01	3.0
1,2,4-Trimethylbenzene	181	3.00E+01	0.88	2.30E-03	9200	4.30	2.90E-01	56
1,3,5-Trimethylbenzene	181	3.00E+01	0.88	2.30E-03	9200	4.30	2.90E-01	56
4-Ethyl toluene	120	4.70E+02	0.86	3.36E-03	330	3.26	1.00E+01	3.0
Trichlorofluoromethane (Freon 11)	137	1.10E+03	1.49	1.09E-01	159	2.53	6.67E+02	2.0
Dichlorodifluoromethane (Freon 12)	122	2.80E+02	1.49	2.79E+00	58	2.16	4.87E+03	1.3
Dichlorotetrafluoroethane (Freon 114)	122	2.80E+02	1.53	2.79E+00	58	2.16	4.87E+03	1.3

TABLE 5-1
Summary of Physical and Chemical Properties of Compounds Detected at H.O.D. Landfill
H.O.D. Landfill RI/FS

COMPOUND	Molecular Weight (g/mole)	Water Solubility (mg/L)	Density (g/cc)	Henry's Law Constant (atm-m ³ /mole)	Koc (ml/g)	Log Kow (ml/g)	Vapor Pressure (mm Hg)	Retardation Factor
Semivolatile Organic Compounds								
Phenol	94	9.30E+04	1.07	4.54E-07	14.2	1.46	3.41E-01	1.1
1,4-Dichlorobenzene	147	7.90E+01	1.46	2.89E-03	1700	3.60	1.18E+00	11
2-Methylphenol	108	3.00E+04	1.03	1.14E-06	500	1.97	2.40E-01	4.0
4-Methylphenol	108	3.00E+04	1.02	4.95E-04	500	1.97	1.10E-01	4.0
2,4-Dimethylphenol	122	4.60E+03 b	1.03		42	2.36	5.90E-02 b	1.3
Naphthalene	128	3.20E+01	0.96	1.11E-03	649	3.45	2.60E-04	4.9
4-Chloroaniline								
2-Methylnaphthalene	142	2.70E+01	1.01	4.08E-04	712	3.43	5.90E-02 d	5.3
Acenaphthene	154	3.42E+00	1.02	9.18E-05	4600	4.00	1.55E-03	29
Dibenzofuran	170	2.10E+01	1.09	2.13E-04	820	3.51	2.00E-02 g	5.9
Diethylphthalate	222	8.96E+02	1.12	1.14E-06	142	2.50	3.50E-03	1.9
Fluorene	116	1.69E+00	1.2	6.42E-05	7300	4.20	7.10E-04	45
Phenanthrene	178	1.00E+00	0.98	1.59E-04	14000	4.46	6.80E-04	85
Anthracene	178	4.50E-02	1.28	1.02E-03	14000	4.45	1.95E-04	85
Fluoranthene	202	2.06E-01	1.25	6.46E-06	38000	4.90	5.00E-06	229
Pyrene	202	1.32E-01	1.27	5.04E-06	38000	4.88	2.50E-06	229
bis(2-Ethylhexyl)phthalate	391	2.85E-01 a	0.98	1.55E-05	692	4.91	8.60E-06 a	5.2
Benzo(b)fluoranthene	252	1.40E-02		1.18E-05	550000	6.06	5.00E-07	3,301
Carbazole	167	1.69E+00 i		9.23E-05	7300 i	3.29	7.10E-04 i	45
Pesticides/PCBs								
4,4'-DDD	320	1.00E-01		7.96E-06	770000	6.20	1.89E-06	4,621
PCB	328	3.10E-02		1.07E-03	530000	6.04	7.70E-05	3,181

TABLE 5-1
Summary of Physical and Chemical Properties of Compounds Detected at H.O.D. Landfill
H.O.D. Landfill RI/FS
Footnotes

The Octanol/Water Partition Coefficient (Kow) is defined as the ratio of the equilibrium concentration C of a dissolved substance in a two-phase system consisting of two largely immiscible solvents, in this case n-octanol and water:

$$Kow = \frac{C_{\text{octanol}}}{C_{\text{water}}}$$

The Kow is ideally dependent only on temperature and pressure. It is a constant without dimensions, and is given in the form of its logarithm to base ten. It is useful as a means to predict soil adsorption, biological uptake, and bioaccumulation. Values are either determined experimentally, or are estimated as follows:

$$Kow = 4.5 - (0.75 * \text{Log Water Solubility in mg/L})$$

Retardation factors are calculated using the following equation:

$$Rf = 1 + (pb/n) * Kd$$

where

Pb = aquifer bulk density (g/cm³) assumed 1.8 g/cm³

n = total porosity of the aquifer, assumed 0.3 (unitless)

Kd = distribution coefficient (mL/g) is calculated as Koc * f_{oc}

and

f_{oc} = organic carbon content of soils, assumed f_{oc} is 0.1%.

Values were obtained from the following sources:

U.S.EPA Superfund Public Health Evaluation Manual (SPEM), 1986

Verslueren, K. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., NY 1983

Weast, R.C. Handbook of Chemistry and Physics, 54th Edition. CRC Press, Cleveland, 1973

TABLE 5-1
Summary of Physical and Chemical Properties of Compounds Detected at H.O.D. Landfill
H.O.D. Landfill RI/FS
Footnotes

Footnotes

a = value estimated using butylbenzylphthalate
b = value estimated using 2,4-dichlorophenol
c = value estimated using benzene
d = value estimated using 2-naphthylamine
e = value estimated using DDT
f = value estimated using dieldrin
g = value estimated using diphenylamine
h = value estimated using diphenyl ether
i = value estimates using fluorene

Definitions of chemical properties:

Water solubility is the maximum concentration of a chemical that dissolves in pure water at a specific temperature and pH. Values are given for a neutral pH and a temperature range of 20 degrees C. The rate at which a chemical is leached from a waste is a function of its solubility in water; more soluble compounds are expected to be leached more readily than less soluble chemicals. The water solubilities presented in literature indicate that the volatile organic compounds are more water soluble than most semivolatile organic compounds (e.g., PAHs and PCBs).

Vapor Pressure (VP) provides an indication of the rate at which a chemical in its pure state volatilizes. Values are given for a temperature range of 20 to 30 degrees C. VP is of primary significance where environmental interfaces such as surface soil/air and surface water/air occur. Chemicals with higher vapor pressures are expected to enter the atmosphere more readily than chemicals with lower vapor pressures.

Density refers to the specific density of a compound relative to pure water, having a density of 1.00. Compounds that have low solubilities and with a density greater than one would be expected to sink in water.

Henry's Law constant, or the compound's air-water partition coefficient, is important in evaluating air exposure pathways. Values for Henry's Law constants were derived experimentally or estimated as follows:

$$H(\text{atm-m}^3/\text{mole}) = \frac{\text{VP (mm Hg)} \times (1 \text{ atm}/760 \text{ mm Hg}) \times \text{MW (g/mole)}}{\text{Water Solubility (g/m}^3\text{)}}$$

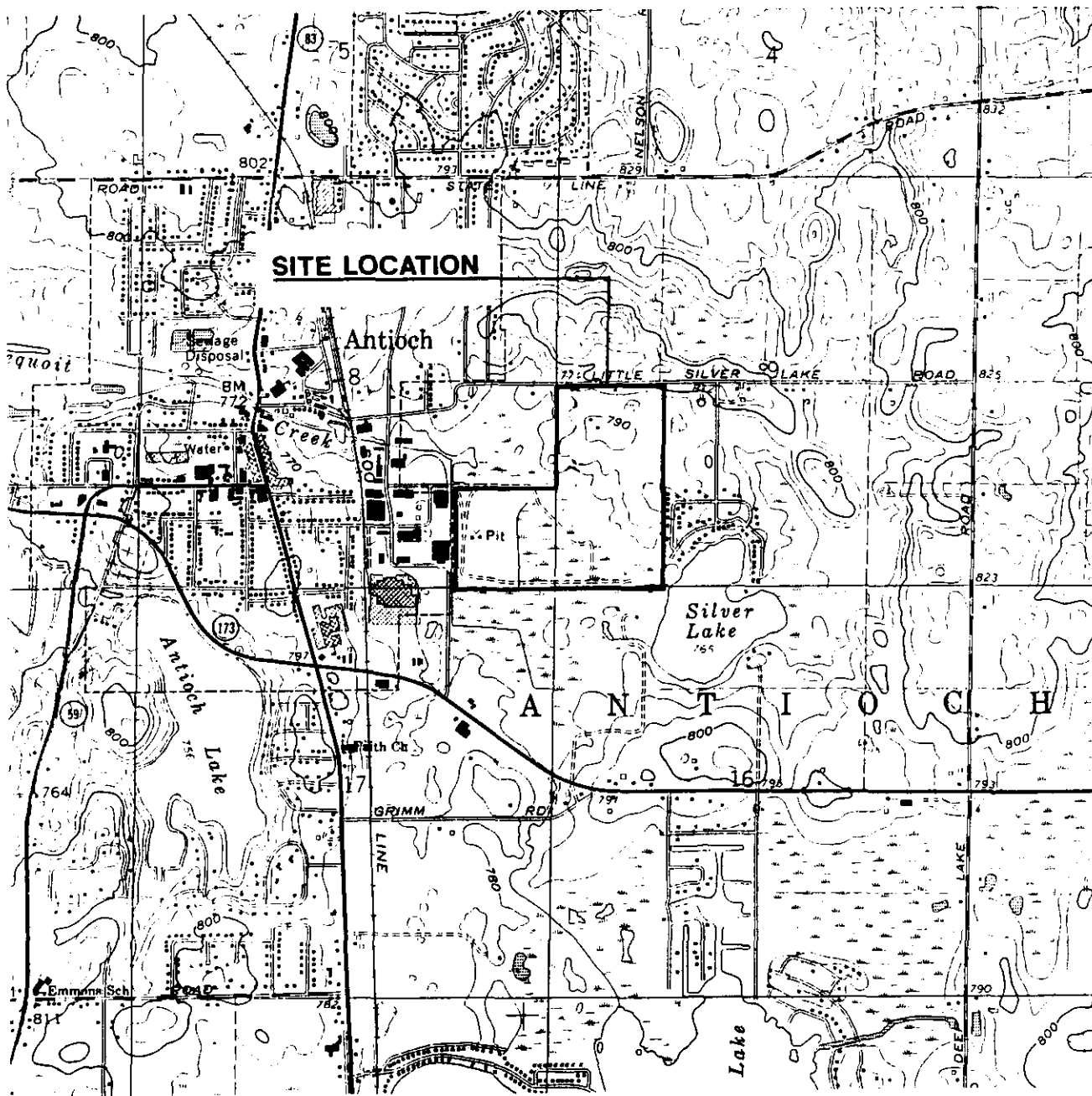
Organic Carbon Partition Coefficient (Koc) is a measure of the tendency for organics to be adsorbed by soil and sediment, and is expressed as:

$$\text{Koc} = \frac{\text{mg chemical adsorbed/kg organic carbon}}{\text{mg chemical dissolved/liter of solution}}$$

The Koc is chemical specific and is largely independent of soil properties. In general, Koc is inversely related to its environmental mobility. Koc is either determined experimentally or estimated as follows:

$$\text{Koc} = (-0.55 \times \log \text{ Water Solubility in mg/l.}) + 3.64$$

QUALITY CONTROL	Graphic Standards CCM 8-5-93 Lead Professional SJC 9-6-93	Technical Review Project Manager ATS 9-21-93	Management Review Other
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NOTES

1. BASE MAP DEVELOPED FROM THE ANTIOCH, ILLINOIS 7.5 MINUTE U.S.G.S. TOPOGRAPHIC QUADRANGLE MAP DATED 1960, PHOTOREVISED 1972.



QUADRANGLE LOCATION



SCALE IN FEET

FIGURE 1

Developed By: SJC Drawn By: CCM
Approved By: Alan J. Schmidt Date: 10/6/93
Reference:
Revisions:

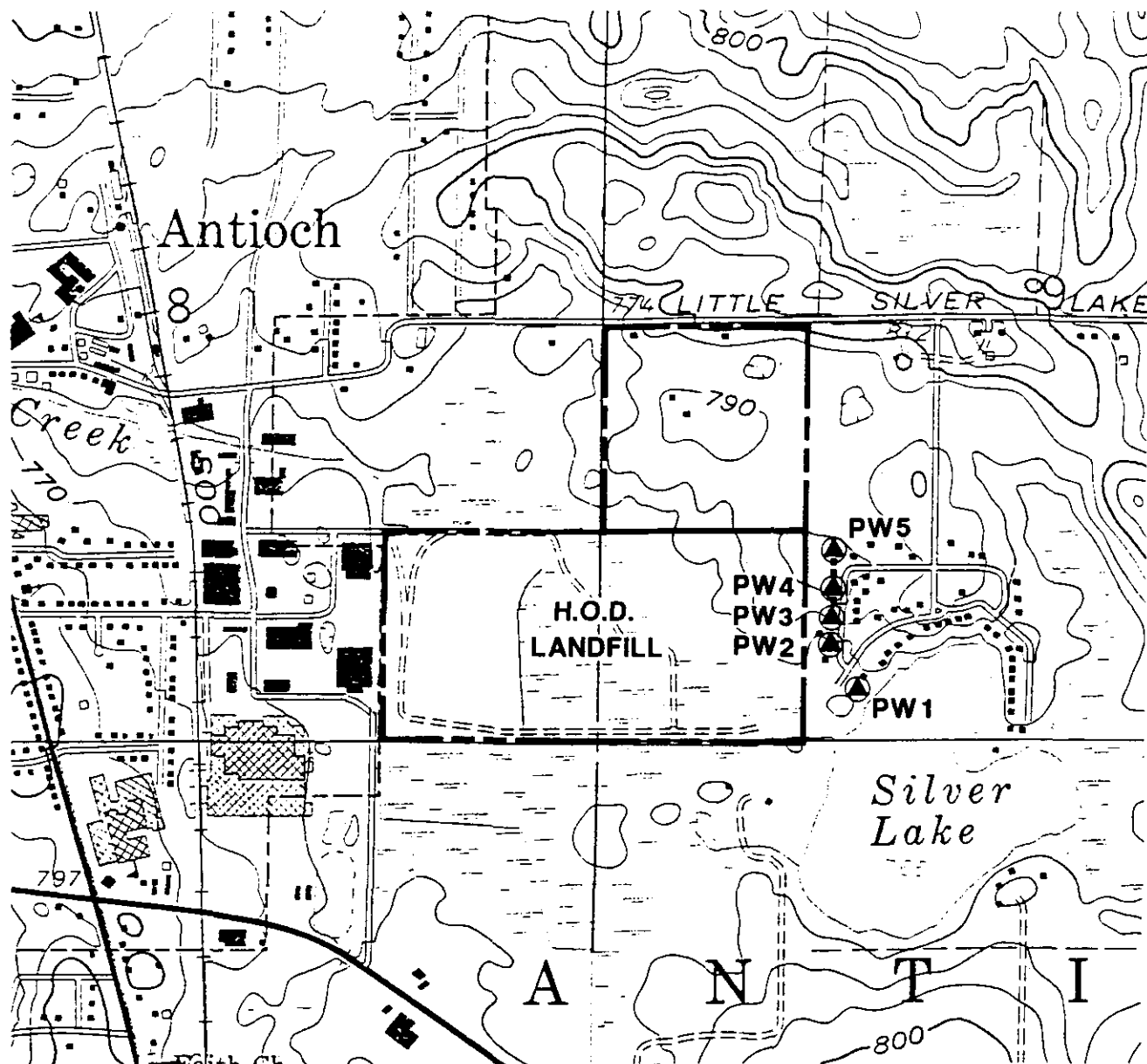
SITE LOCATION MAP

REMEDIAL INVESTIGATION
H.O.D. LANDFILL
WASTE MANAGEMENT OF ILLINOIS, INC.
ANTIOCH, ILLINOIS

Drawing Number
10010201 A1



QUALITY CONTROL	Graphic Standards CCM 8-5-93	Technical Review <i>AS 9-21-93</i>	Management Review
	Lead Professional <i>SJC 9-14-93</i>	Project Manager	Other



LEGEND

▲ PW1 PRIVATE WELL SAMPLING LOCATION AND NUMBER

NOTES

1. BASE MAP DEVELOPED FROM THE ANTIOCH, ILLINOIS-WISCONSIN 7.5 MINUTE U.S.G.S. TOPOGRAPHIC QUAD-RANGLE MAP, DATED 1960, PHOTO-REVISED 1972.

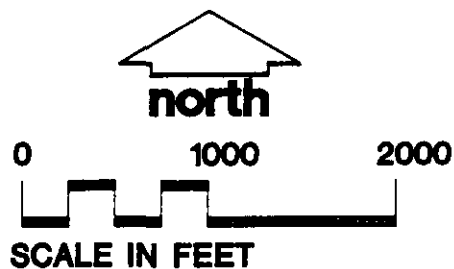


FIGURE 3

Developed By: *SJC* Drawn By: CCM
 Approved By: *Alana J. Schindler* Date: *10/10/93*
 Reference:
 Revisions:

PRIVATE WATER SUPPLY WELL SAMPLING LOCATIONS

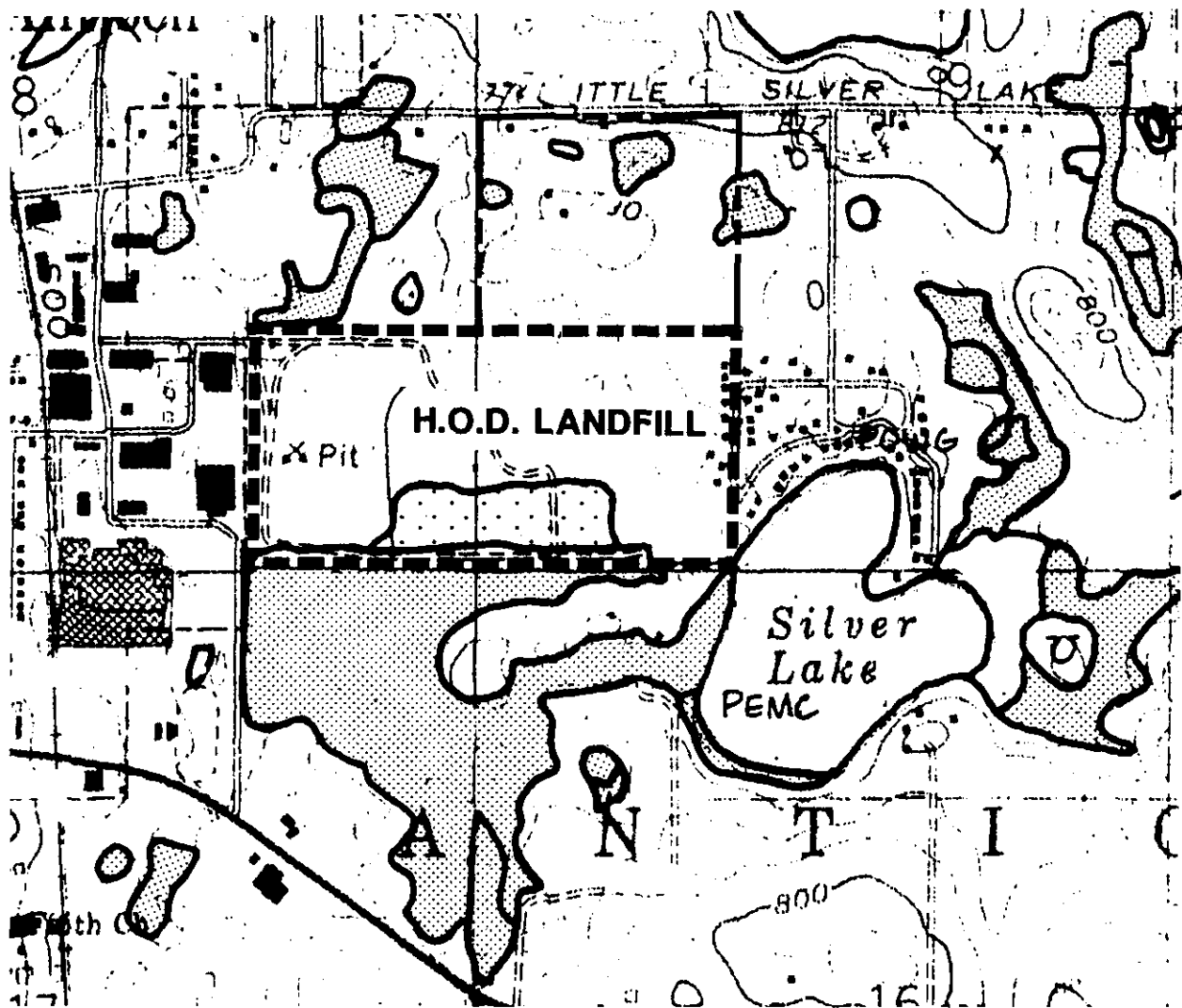
REMEDIAL INVESTIGATION
 H.O.D. LANDFILL
 WASTE MANAGEMENT OF ILLINOIS, INC.
 ANTIOCH, ILLINOIS

Drawing Number
 10010201

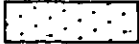

A3

WARZYN

QUALITY CONTROL
 Graphic Standards CCM 8-5-93
 Lead Professional SJD 9-14-93
 Technical Review AIS 9-21-93
 Management Review
 Other



LEGEND

-  SEASONAL WETLAND 1, 2
-  WETLAND 1, 2

NOTES

1. BASE MAP DEVELOPED FROM THE ANTIOCH, ILLINOIS 7.5 MINUTE U.S.G.S. TOPOGRAPHIC QUADRANGLE MAP, DATED 1960, PHOTOREVISED 1972.
2. WETLAND AREAS IDENTIFIED BY ANALYSIS OF HIGH ALTITUDE AERIAL PHOTOGRAPHY. AREAS HAVE NOT BEEN FIELD VERIFIED.

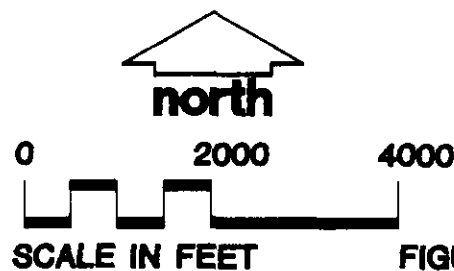


FIGURE 4

Developed By: SJC
 Drawn By: CCM
 Approved By: *Alan R. Schiltz* Date: 10/6/93
 Reference:
 Revisions:

WETLANDS INVENTORY MAP

REMEDIAL INVESTIGATION
 H.O.D. LANDFILL
 WASTE MANAGEMENT OF ILLINOIS, INC.
 ANTIOCH, ILLINOIS

Drawing Number
 10010201 **A4**



QUALITY CONTROL	Graphic Standards CCM 8-5-93	Technical Review <i>AS 9-21-93</i>	Management Review
	Lead Professional SJC 9-11-93	Project Manager	Other

SYSTEM	SERIES	GROUP OR FORMATION	AQUIFER	LOG	THICKNESS (FT)	DESCRIPTION
QUATERNARY	PLEISTOCENE		Sands and Gravels		90-325	Unconsolidated glacial deposits pebbly clay (till), silt, sand and gravel Alluvial silts and sands along streams
					Fissure Fillings	Shale, sandy, brown to black
SILURIAN	NIAGARAN	Racine	Silurian		0-180	Dolomite, very pure to argillaceous, silty, cherty; reefs in upper part
		Sugar Run				Dolomite, slightly argillaceous and silty
		Joliet				Dolomite, very pure to shaly and shale, dolomitic; white, light gray, green, pink, maroon
	ALEXANDRIAN	Kankakee			0-90	Dolomite, pure top 1'-2', thin green shale partings, base glauconitic
		Elwood				Dolomite, slightly argillaceous, abundant layered white chert
		Wilhelmi				Dolomite, gray, argillaceous and becomes dolomitic shale at base
ORDOVICIAN	CINCINNATIAN	Maquoketa			100-240	Shale, red; oolites Shale, silty, dolomitic, greenish gray, weak (Upper unit) Dolomite and limestone, white, light gray, interbedded shale (Middle unit) Shale, dolomitic, brown, gray (Lower unit)
	CHAMPLAINIAN	Galena	Galena-Platteville		270-335	Dolomite, and/or limestone, cherty (Lower part) Dolomite, shale partings, speckled Dolomite and/or limestone, cherty, sandy at base
		Platteville				
		Glenwood	Glenwood-St. Peter			
		St. Peter				
CAMBRIAN	CROIXAN	Eminence	Eminence-Potosi		0-100	Dolomite, light colored, sandy, thin sandstones Dolomite, fine-grained, gray to brown, drusy quartz
		Potosi				
		Franconia	Franconia		40-80	Dolomite, sandstone and shale, glauconitic, green to red, micaceous
		Ironton	Ironton-Galesville		100-190	Sandstone, fine to coarse grained, well sorted; upper part dolomitic
		Galesville				
		Eau Claire			385-475	Shale and siltstone, dolomitic, glauconitic; sandstone, dolomitic, glauconitic
		Elmhurst Member	Elmhurst-Mt. Simon		1200-2000	Sandstone, coarse grained, white, red in lower half; lenses of shale and siltstone, red, micaceous
		Mt. Simon	Elmhurst-Mt. Simon aquifer			
PRE-CAMBRIAN						Granitic Rocks

NOTES

1. STRATIGRAPHIC COLUMN ADAPTED FROM PUBLIC GROUNDWATER SUPPLIES IN LAKE COUNTY, ILLINOIS. STATE WATER SURVEY, URBANA, ILLINOIS BY DOROTHY M. WOLLER AND JAMES P. GIBB, 1976.

FIGURE 5

WARZYN INC.	Developed By: <i>SJC</i>	Drawn By: CCM	STRATIGRAPHIC COLUMN FOR NORTHEASTERN ILLINOIS REMEDIAL INVESTIGATION H.O.D. LANDFILL WASTE MANAGEMENT OF ILLINOIS, INC. ANTIOCH, ILLINOIS	Drawing Number	
	Approved By: <i>Alan J. Schmitt</i>	Date: <i>10/6/93</i>		10010201	A5
	Reference:				
	Revisions:				


QUALITY CONTROL	Graphic Standards CCM 8-5-93 Lead Professional SJC 9-16-93	Technical Review <i>ATS 9-21-93</i> Project Manager	Management Review Other
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TIME STRATIGRAPHY				ROCK STRATIGRAPHY				MORPHOSTRATIGRAPHY
SYSTEM	SERIES	STAGE	SUBSTAGE					
QUATERNARY	PLEISTOCENE	WISCONSINAN	HOLOCENE					Lake Border Drifts Zion City Drift Highland Park D. Bladgett D. Deerfield D. Park Ridge D. Tinley D. Valparaiso Drifts Palatine D. Clarendon D. Roselle D. Westmont D. Keeneyville D. Wheaton D. West Chicago D.
			VALDERAN					Valparaiso Drifts Fox Lake D. Cary D. West Chicago D.
			TWO-CREEKAN					Manhattan D. Wilton Center D. Rockdale D. St. Anne D. Minooka D. Marseilles D. St. Charles D.
			WOOD-FORDIAN	Richland Loess Henry Formation Batavia, Mackinaw, and Wasco Members Equality Formation Carmi and Dutton Members Wedron Formation	Cahokia Alluvium Parkland Sand Grayslake Peat Lake Michigan Formation Ravinia Sand Mem.	Wadsworth Till Member Haeger Till Member Yorkville Till Member Malden Till Member Tiskilwa Till Member	Barlina D. Huntley D. Gilberts D. Elburn D. Bloomington Drifts Morengo D.	

NOTES

1. STRATIGRAPHIC COLUMN TAKEN FROM SUMMARY OF THE GEOLOGY OF THE CHICAGO AREA. ILLINOIS STATE GEOLOGICAL SURVEY CIRCULAR 460 BY H.B. WILLMAN.

FIGURE 6

WARZYN INC.	Developed By: <i>SJC</i>	Drawn By: CCM	PLEISTOCENE STRATIGRAPHIC COLUMN FOR CHICAGO AREA REMEDIAL INVESTIGATION H.O.D. LANDFILL WASTE MANAGEMENT OF ILLINOIS, INC. ANTIOCH, ILLINOIS	Drawing Number
	Approved By: <i>Alamp. Schmitt</i>	Date: <i>10/6/93</i>		10010201 A6
	Reference:			
	Revisions:			
				

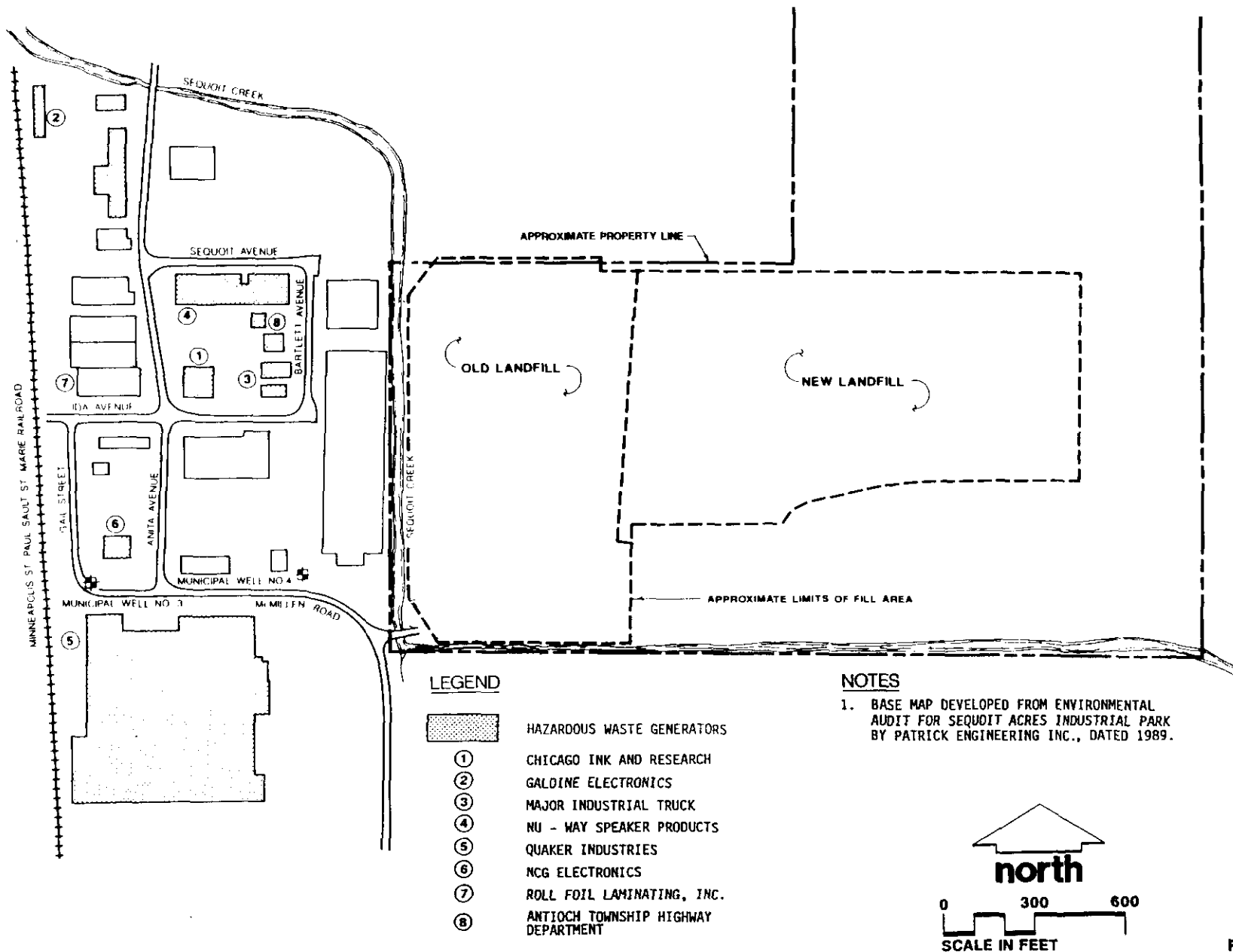


FIGURE 7

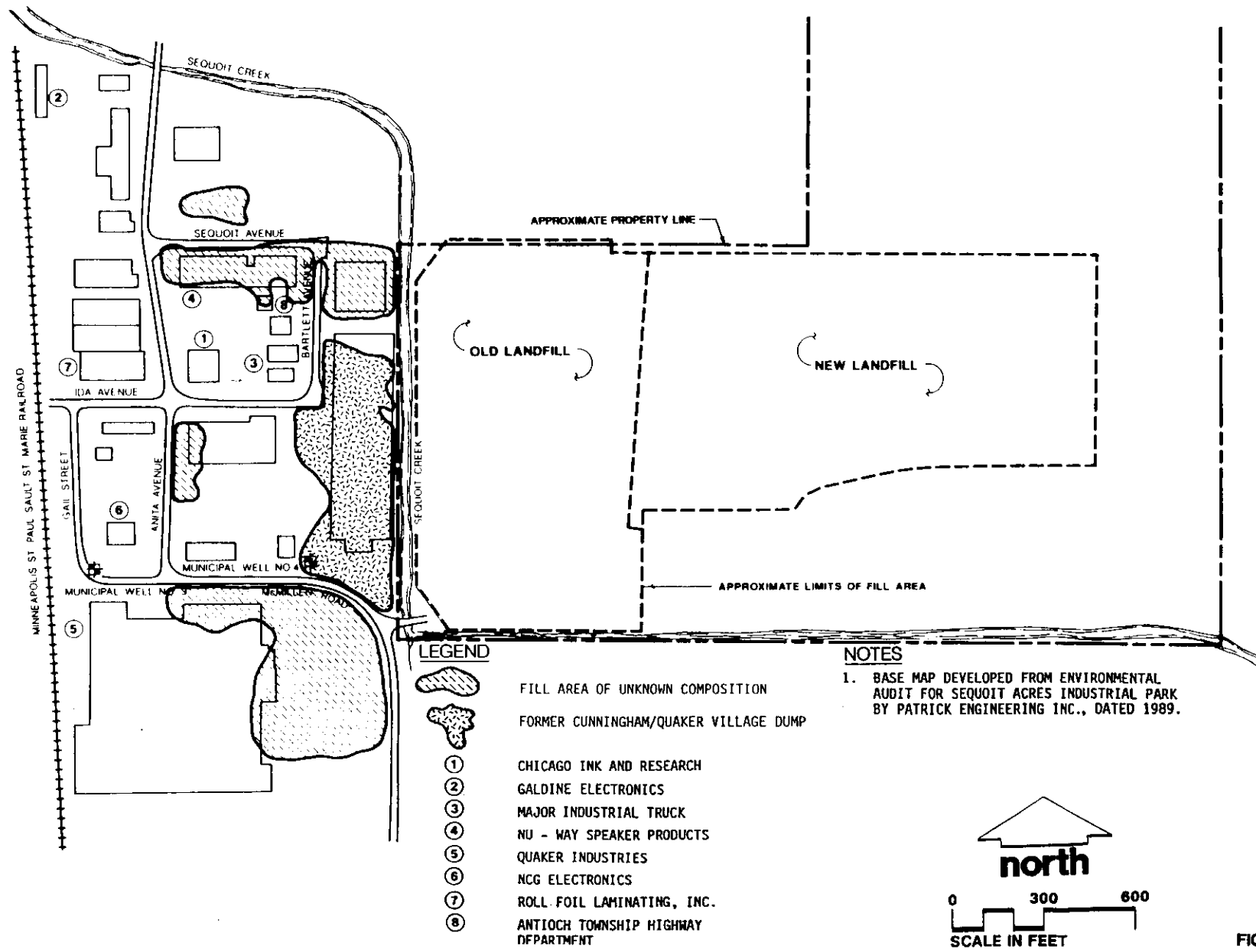
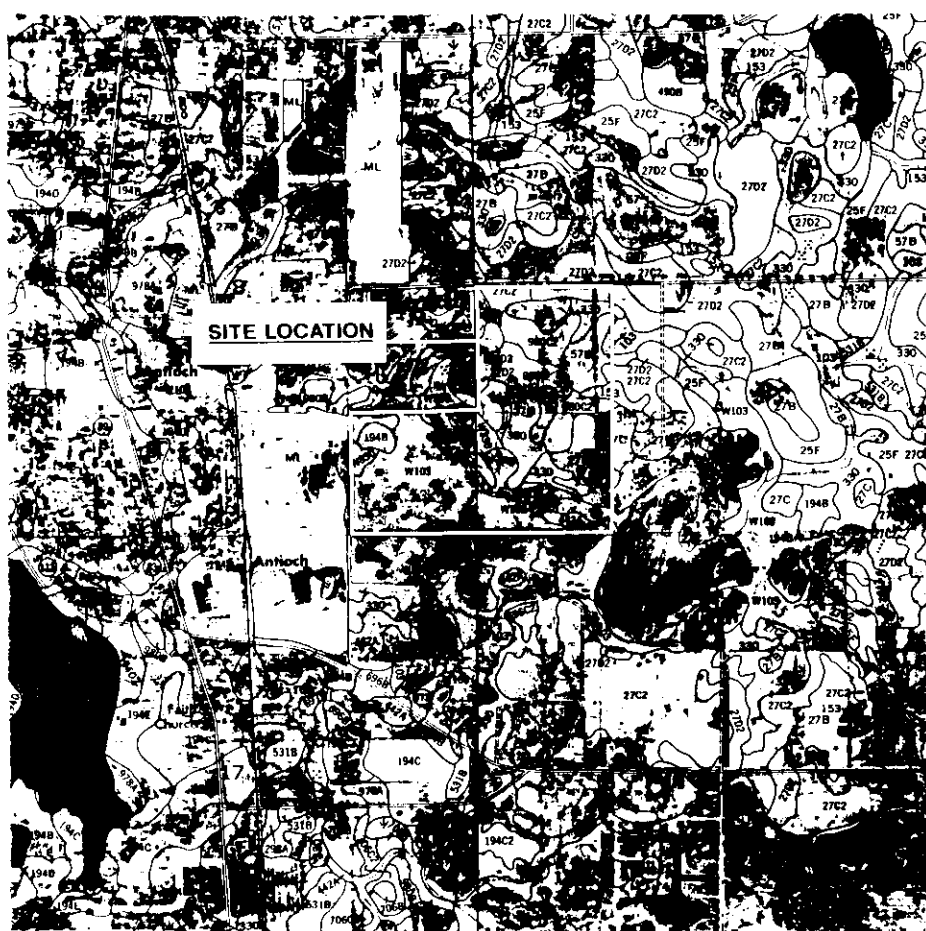


FIGURE 8



SOIL LEGEND

A number shows the soil type or a group of undifferentiated soils. A capital letter, A, B, C, D, E, F, or G, shows the slope. Wherever the number shows a wet soil. Most symbols without a slope letter are those of nearly level soils. A final number, 2, after the slope letter indicates an eroded soil.

SYMBOL	NAME	SYMBOL	NAME
21F	annapolis loam, 15 to 30 percent slopes	365	apalachicola silt loam
25G	hennepin loam, 30 to 60 percent slopes	367	beach sand
27B	miom silt loam, 2 to 4 percent slopes	370B	scarsville silt loam, 1 to 4 percent slopes
27C	miom silt loam, 4 to 7 percent slopes	370C	scarsville silt loam, 4 to 7 percent slopes, eroded
27C2	miom silt loam, 4 to 7 percent slopes, eroded	442A	mundelmin silt loam, 0 to 2 percent slopes
27D	miom silt loam, 7 to 12 percent slopes	442B	mundelmin silt loam, 2 to 4 percent slopes
27D2	miom silt loam, 7 to 12 percent slopes, eroded	442A	barrington silt loam, 0 to 2 percent slopes
V54	plainsfield sand, slightly acid variant, 1 to 4 percent slopes	442B	barrington silt loam, 2 to 4 percent slopes
57B	montmorency silt loam, 2 to 4 percent slopes	455	manitowish silt loam
57C2	montmorency silt loam, 4 to 7 percent slopes, eroded	490A	osell silt loam, 0 to 2 percent slopes
67	harper silt loam	490B	osell silt loam, 2 to 4 percent slopes
93F	rodman gravelly loam, 15 to 50 percent slopes	495A	conwin silt loam, 0 to 2 percent slopes
W07	houghton peat, wet	495B	conwin silt loam, 2 to 4 percent slopes
W03	houghton muck, wet	513	granby loamy fine sand
W07	seawall silty clay loam	531B	markham silt loam, 1 to 4 percent slopes
146A	l silt loam, 3 to 2 percent slopes	531B2	markham silt loam, 2 to 4 percent slopes, eroded
146B	elbert silt loam, 2 to 4 percent slopes	531C	markham silt loam, 4 to 7 percent slopes
153	prila silty clay loam	531C2	markham silt loam, 4 to 7 percent slopes, eroded
189A	montmorency silt loam, 0 to 2 percent slopes	531D2	markham silt loam, 7 to 12 percent slopes, eroded
189B	montmorency silt loam, 2 to 4 percent slopes	699A	zurich silt loam, 0 to 2 percent slopes
192A	day silt loam, 0 to 2 percent slopes	699B	zurich silt loam, 2 to 4 percent slopes
192B	day silt loam, 2 to 4 percent slopes	699C	zurich silt loam, 4 to 7 percent slopes
194B	marley silt loam, 2 to 4 percent slopes	699C2	zurich silt loam, 4 to 7 percent slopes, eroded
194B2	marley silt loam, 2 to 4 percent slopes, eroded	699D	zurich silt loam, 7 to 12 percent slopes, eroded
194C	marley silt loam, 4 to 7 percent slopes	697A	wauconda silt loam, 0 to 2 percent slopes
194C2	marley silt loam, 4 to 7 percent slopes, eroded	697B	wauconda silt loam, 2 to 4 percent slopes
194D	marley silt loam, 7 to 12 percent slopes	698A	grays silt loam, 0 to 2 percent slopes
194D2	marley silt loam, 7 to 12 percent slopes, eroded	698B	grays silt loam, 2 to 4 percent slopes
194E	marley silt loam, 12 to 25 percent slopes	706B	beaver silt loam, 1 to 4 percent slopes
194E2	marley silt loam, 12 to 25 percent slopes, eroded	706C2	beaver silt loam, 4 to 10 percent slopes, eroded
222	askum silty clay loam	978A	wauconda and becher silt loams, 0 to 2 percent slopes
228A	naponee silt loam, 0 to 2 percent slopes	978B	wauconda and becher silt loams, 2 to 4 percent slopes
228B	naponee silt loam, 2 to 4 percent slopes	979A	grays and markham silt loams, 0 to 2 percent slopes
228C2	naponee silt loam, 4 to 7 percent slopes, eroded	979B	grays and markham silt loams, 2 to 4 percent slopes
298A	becher silt loam, 0 to 2 percent slopes	980B	zurich and marley silt loams, 2 to 4 percent slopes
298B	becher silt loam, 2 to 4 percent slopes	980C2	zurich and marley silt loams, 4 to 7 percent slopes, eroded
320A	frankfort silt loam, 0 to 2 percent slopes	981A	wauconda and frankfort silt loams, 0 to 2 percent slopes
320B	frankfort silt loam, 2 to 4 percent slopes	981B	wauconda and frankfort silt loams, 2 to 4 percent slopes
322C2	clayton loam, 1 to 10 percent slopes, eroded	982A	apalachicola and naponee silt loams, 0 to 2 percent slopes
325A	crexson loam, 0 to 2 percent slopes	982B	apalachicola and naponee silt loams, 2 to 4 percent slopes
325B	crexson loam, 2 to 4 percent slopes	983B	zurich and naponee silt loams, 2 to 4 percent slopes
327A	fox loam, 0 to 2 percent slopes	984B	barrington and vana silt loams, 2 to 4 percent slopes
327B	fox loam, 2 to 4 percent slopes	985A	mundelmin and elliot silt loams, 0 to 2 percent slopes
327C2	fox loam, 4 to 7 percent slopes, eroded	985B	mundelmin and elliot silt loams, 2 to 4 percent slopes
330	pestone silty clay loam	GA	barrow area
W330	pestone silty clay loam, wet	GP	gravel pits
		MA	mud
		ML	moist land

NOTES

- SCS SOILS MAP WAS OBTAINED FROM THE SOIL SURVEY OF LAKE COUNTY, ILLINOIS, DATED SEPTEMBER 1970.

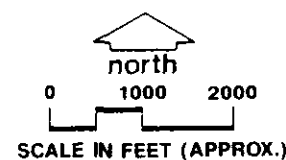


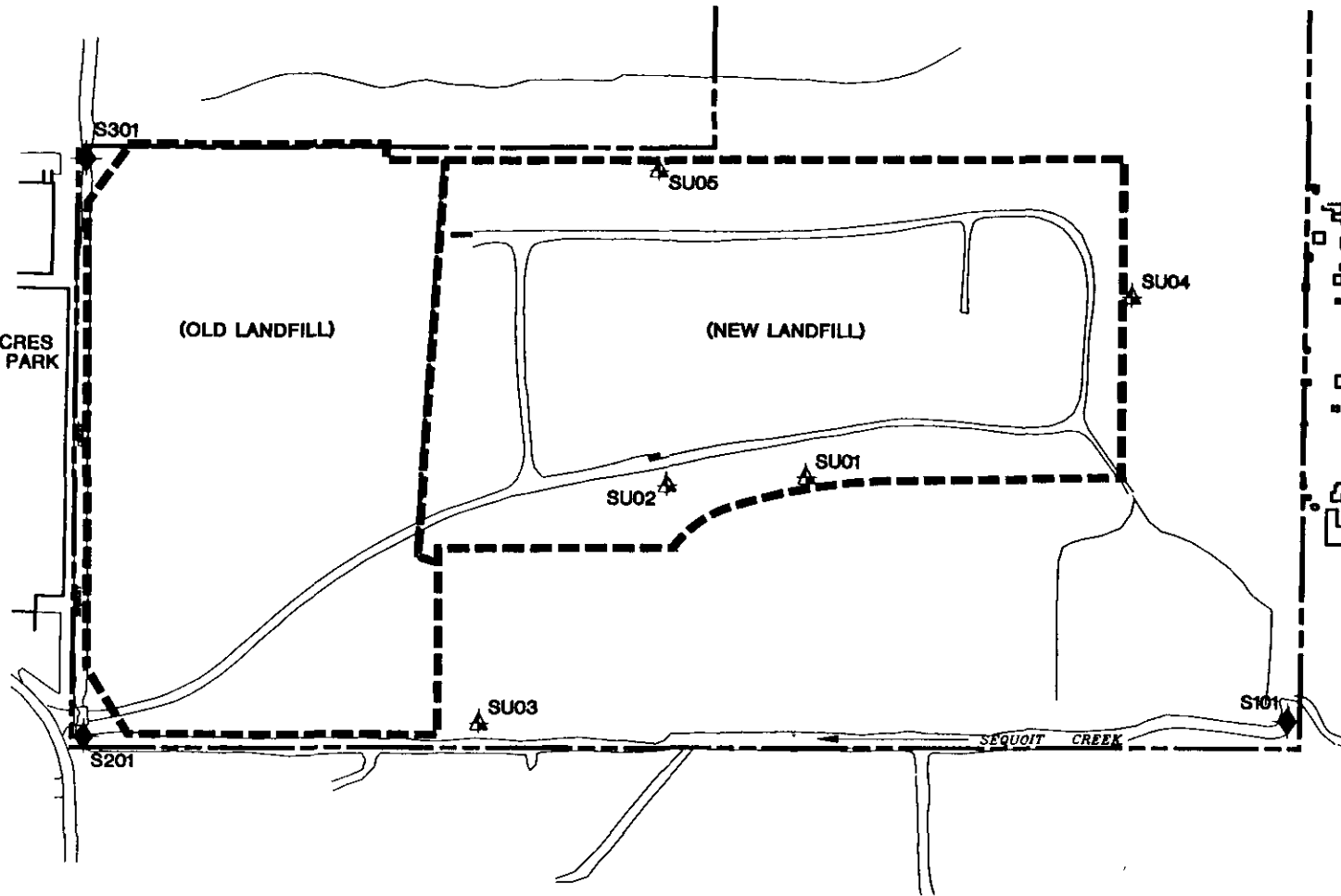
FIGURE 9

Developed By: SJC
 Drawn By: CCM
 Approved By: *Alfred Schickel*
 Date: 10/6/93
 Reference:
 Revisions:

SURFICIAL SOILS MAP
 REMEDIAL INVESTIGATION
 H.O.D. LANDFILL
 WASTE MANAGEMENT OF ILLINOIS, INC.
 JANTOCH, ILLINOIS
 Drawing Number: 10010201
 B

WARZY

SEQUOIT ACRES INDUSTRIAL PARK



LEGEND

- APPROXIMATE PROPERTY LINE
- APPROXIMATE LIMITS OF LANDFILLED AREA
- ACCESS ROAD
- BUILDING
- S202 SURFACE WATER MONITORING LOCATION AND NUMBER
- SU01 WARZYN SURFACE SOIL SAMPLING LOCATION AND NUMBER

NOTES

1. REFER TO DRAWING 10010201-F2 FOR ADDITIONAL NOTES AND LEGEND.
2. BASE MAP DEVELOPED FROM AN AERO-METRIC ENGINEERING INC. SURVEY.
3. INVESTIGATION POINTS HAVE BEEN LOCATED BASED ON GENTILE AND ASSOCIATES, INC. SURVEY DURING JUNE AND JULY 1993.

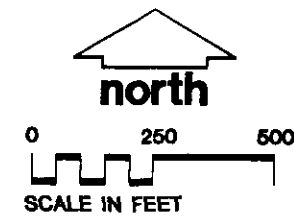
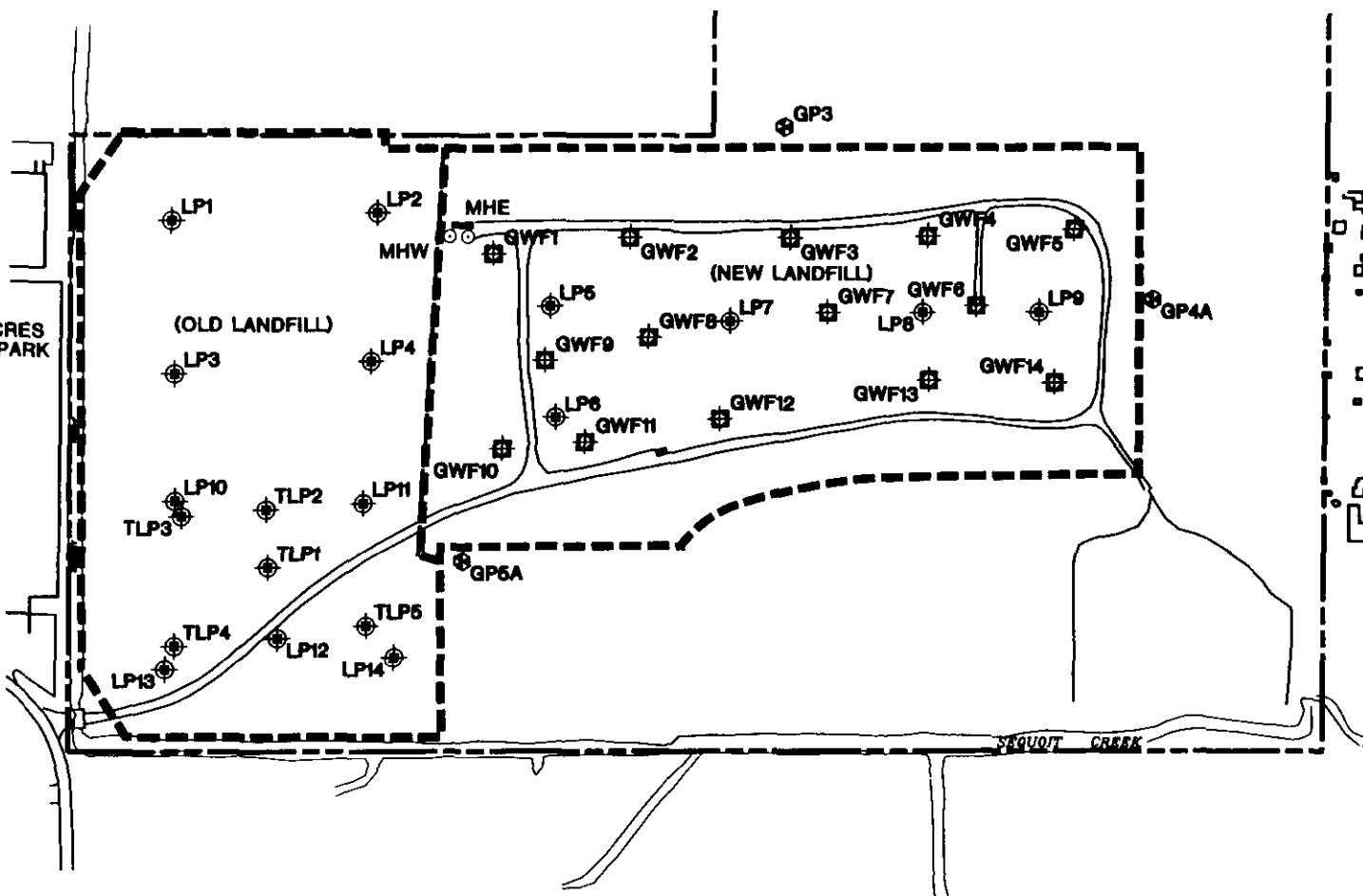


FIGURE 10

SEQUOIT ACRES INDUSTRIAL PARK



LEGEND

- APPROXIMATE PROPERTY LINE
- APPROXIMATE LIMITS OF LANDFILLED AREA
- ACCESS ROAD
- BUILDING
- MHE/MHW LEACHATE MANHOLE EAST/LEACHATE MANHOLE WEST

- LP1 WARZYN LEACHATE PIEZOMETER LOCATION AND NUMBER
- TLP1 TEMPORARY LEACHATE PIEZOMETER LOCATION AND NUMBER
- GP5A WARZYN GAS PROBE LOCATION AND NUMBER
- GWF1 LANDFILL GAS FLARE LOCATION AND NUMBER

NOTES

1. REFER TO DRAWING 10010201-F2 FOR ADDITIONAL NOTES AND LEGEND.
2. BASE MAP DEVELOPED FROM AN AERO-METRIC ENGINEERING INC. SURVEY.
3. INVESTIGATION POINTS HAVE BEEN LOCATED BASED ON GENTILE AND ASSOCIATES, INC. SURVEY PERFORMED DURING JUNE AND JULY, 1993.



FIGURE 11

LEACHATE PIEZOMETER/GAS WELL LOCATION MAP

REMEDIAL INVESTIGATION

H.O.D. LANDFILL

WASTE MANAGEMENT OF ILLINOIS, INC.

ANTHONY T. KOS

Drawing Number 10010201



Developed By: SJC
 Drawn By: CCM
 Approved By: *[Signature]*
 Reference: *[Signature]*
 Resigned: *[Signature]*

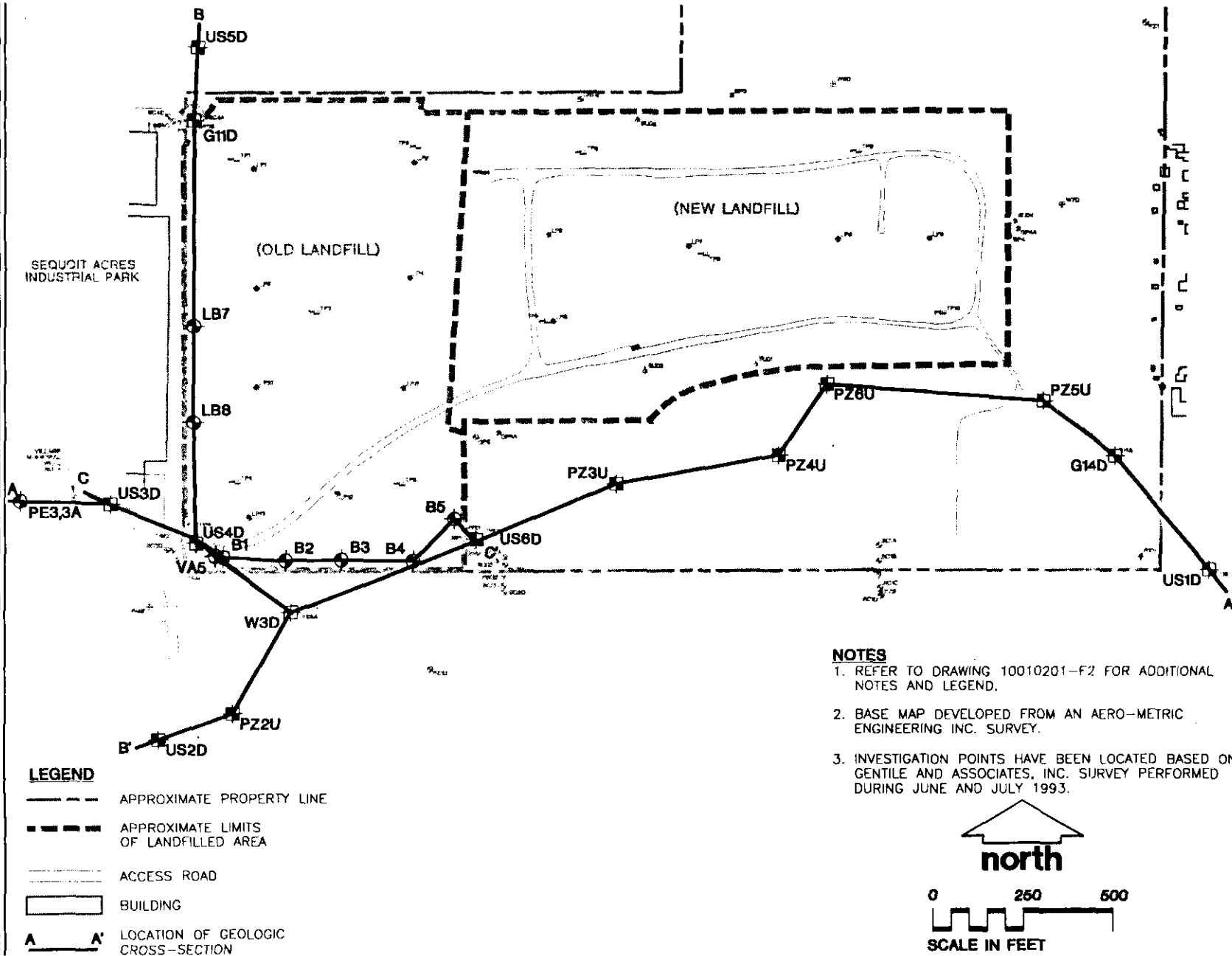


FIGURE 12

GEOLOGIC CROSS-SECTION LOCATION MAP

REMEDIAL INVESTIGATION

H.O.D. LANDFILL

WASTE MANAGEMENT OF ILLINOIS, INC.

ATTORNEY AT LAW

Drawing Number
10010201 E



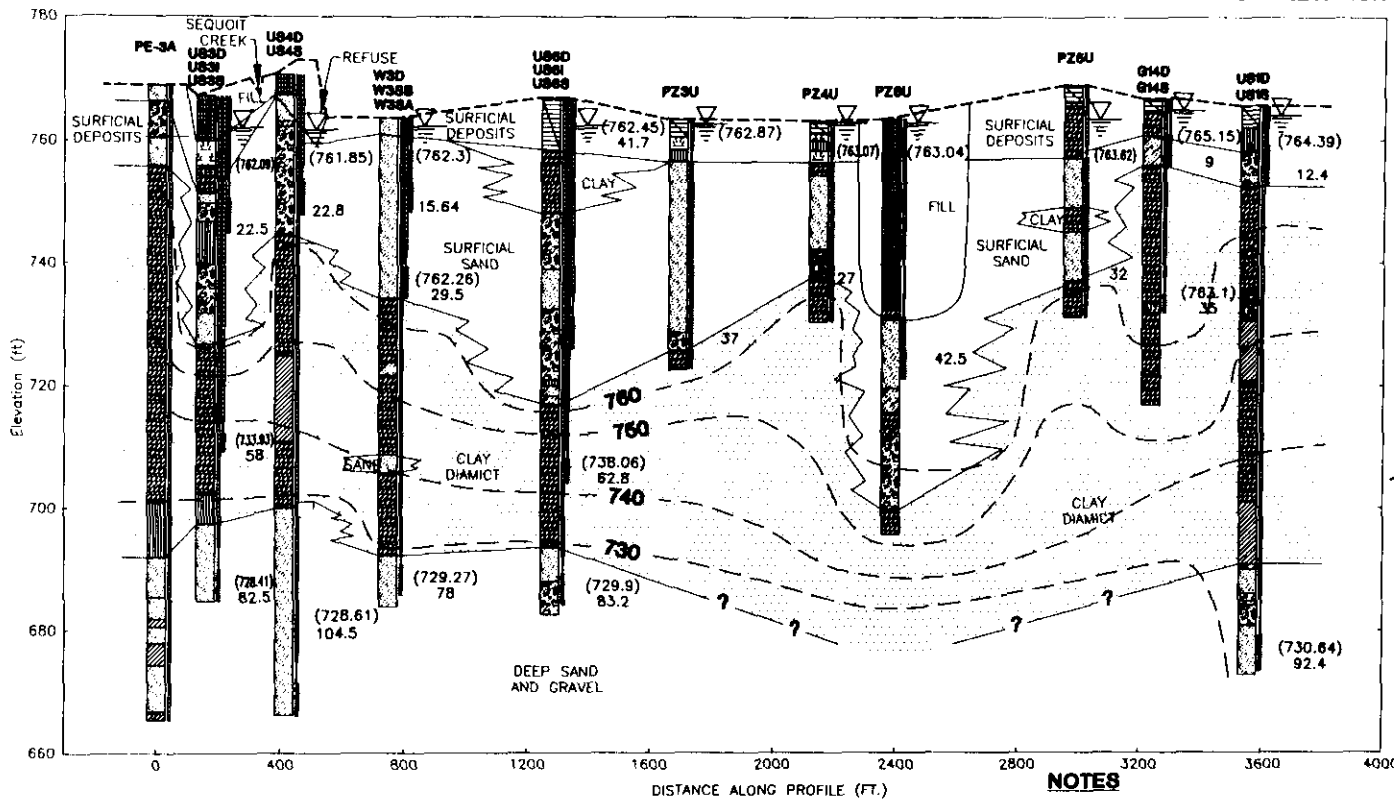
Developed By: SJC Drawn By: CCM

Approved By: *Warzyk* Date: 11/19/93

Reference:

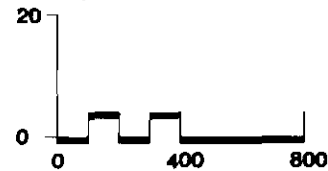
Revisions:

WEST ELEVATION



SECTION A - A'

CROSS SECTION SCALE



SCALE IN FEET

VERTICAL EXAGGERATION: TWENTY TIMES

EAST ELEVATION

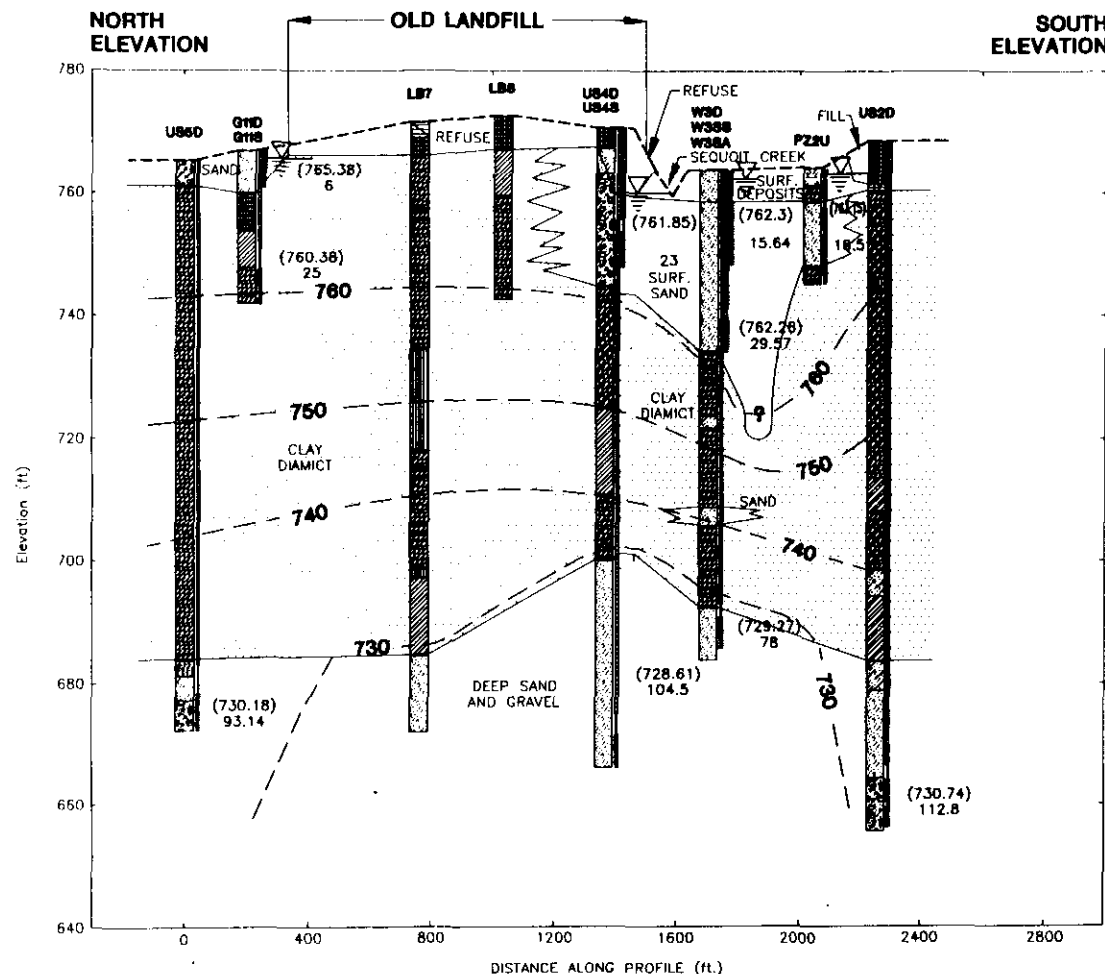
LEGEND

- SAND
- SILTY SAND
- CLAYEY SAND
- CLAYEY GRAVEL
- SAND AND GRAVEL
- SAND AND GRAVEL, SOME SILT AND CLAY
- SAND AND GRAVEL, SOME CLAY
- TOPSOIL
- PAVEMENT
- FILL OR REFUSE
- SILT
- SILTY CLAY
- LEAN CLAY
- EXISTING GROUND SURFACE
- 760 GROUNDWATER EQUIPOTENTIAL LINE (CONTOUR INTERVAL = 10 FT.)
- 740 GROUNDWATER EQUIPOTENTIAL LINE (CONTOUR INTERVAL = 10 FT.)
- 730 GROUNDWATER EQUIPOTENTIAL LINE (CONTOUR INTERVAL = 10 FT.)
- 738.06 GROUNDWATER ELEVATION
- 82.8 TOTAL DEPTH OF WELL IN FEET BELOW GROUND SURFACE
- BACKFILLED WITH BENTONITE
- 2" I.D. RISER
- 2" I.D. SLOTTED WELL SCREEN
- SURFICIAL SAND WELL WATER LEVELS

NOTES

1. THE STRATUM LINES ARE BASED ON INTERPOLATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.
2. FOR THE PURPOSE OF ILLUSTRATING SUBSOIL CONDITIONS ON THE CROSS-SECTIONS, SOME OF THE BORING LOGS HAVE BEEN SIMPLIFIED. FOR A DETAILED DESCRIPTION OF SUBSURFACE CONDITIONS AT INDIVIDUAL BORINGS, REFER TO SOIL BORING LOGS. (APPENDED TO REPORT)
3. COMPLETE MONITORING WELL INSTALLATION DETAILS ARE APPENDED TO REPORT.
4. CROSS-SECTION HAS BEEN EXAGGERATED TWENTY TIMES.
5. HORIZONTAL DISTANCES ARE MEASURED WITH RESPECT TO THE CENTER OF EACH SOIL BORING LOCATION.
6. ELEVATIONS ARE SHOWN IN REFERENCE TO U.S.G.S. DATUM.
7. QUESTION MARKS INDICATE THE CORRELATION OR EQUIPOTENTIAL LINES ARE INFERRED.
8. GROUNDWATER ELEVATIONS ARE BASED ON MEASUREMENTS OBTAINED BY WARZYN INC. ON JUNE 8 AND 9, 1993. CONTOURS ARE EXTRAPOLATED BASED ON CALCULATED VERTICAL HYDROLOGIC GRADIENTS. SEE SECTION 3.7 OF REPORT.
9. CLAY FILL MATERIAL SHOWN AT SOIL BORING PZ6U IN CROSS SECTION IS PROBABLY ASSOCIATED WITH THE CLAY SEAL INSTALLED ALONG THE SOUTHERN PORTION OF THE NEW LANDFILL (SEE DRAWING 10010201-F4).

FIGURE 13



CROSS SECTION SCALE



SCALE IN FEET
 VERTICAL EXAGGERATION: TWENTY TIMES

LEGEND

- SAND
- SILTY SAND
- CLAYEY SAND
- CLAYEY GRAVEL
- SAND AND GRAVEL
- SAND AND GRAVEL, SOME SILT AND CLAY
- SAND AND GRAVEL, SOME CLAY
- TOPSOIL
- PAVEMENT
- FILL OR REFUSE
- SILT
- SILTY CLAY
- LEAN CLAY

760 GROUNDWATER EQUIPOTENTIAL LINE (CONTOUR INTERVAL 10 FT.)

(730.74) GROUNDWATER ELEVATION

112.8 TOTAL DEPTH OF WELL IN FEET BELOW GROUND SURFACE

BACKFILLED WITH BENTONITE

2" I.D. RISER

2" I.D. SLOTTED WELL SCREEN

SURFICIAL SAND WELL WATER LEVELS

NOTES

1. THE STRATUM LINES ARE BASED ON INTERPOLATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.
2. FOR THE PURPOSE OF ILLUSTRATING SUBSOIL CONDITIONS ON THE CROSS-SECTIONS, SOME OF THE BORING LOGS HAVE BEEN SIMPLIFIED. FOR A DETAILED DESCRIPTION OF SUBSURFACE CONDITIONS AT INDIVIDUAL BORINGS, REFER TO SOIL BORING LOGS. (APPENDED TO REPORT)
3. COMPLETE MONITORING WELL INSTALLATION DETAILS ARE APPENDED TO REPORT.
4. CROSS-SECTION HAS BEEN EXAGGERATED TWENTY TIMES.
5. HORIZONTAL DISTANCES ARE MEASURED WITH RESPECT TO THE CENTER OF EACH SOIL BORING LOCATION.
6. ELEVATIONS ARE SHOWN IN REFERENCE TO U.S.G.S. DATUM.
7. QUESTION MARKS INDICATE CORRELATION OR EQUIPOTENTIAL LINES ARE INFERRED.
8. GROUNDWATER ELEVATIONS ARE BASED ON MEASUREMENTS OBTAINED BY WARZYN INC. ON JUNE 8 AND 9, 1993. CONTOURS ARE EXTRAPOLATED BASED ON CALCULATED VERTICAL HYDROLOGIC GRADIENTS. SEE SECTION 3.7 OF REPORT.

FIGURE 14

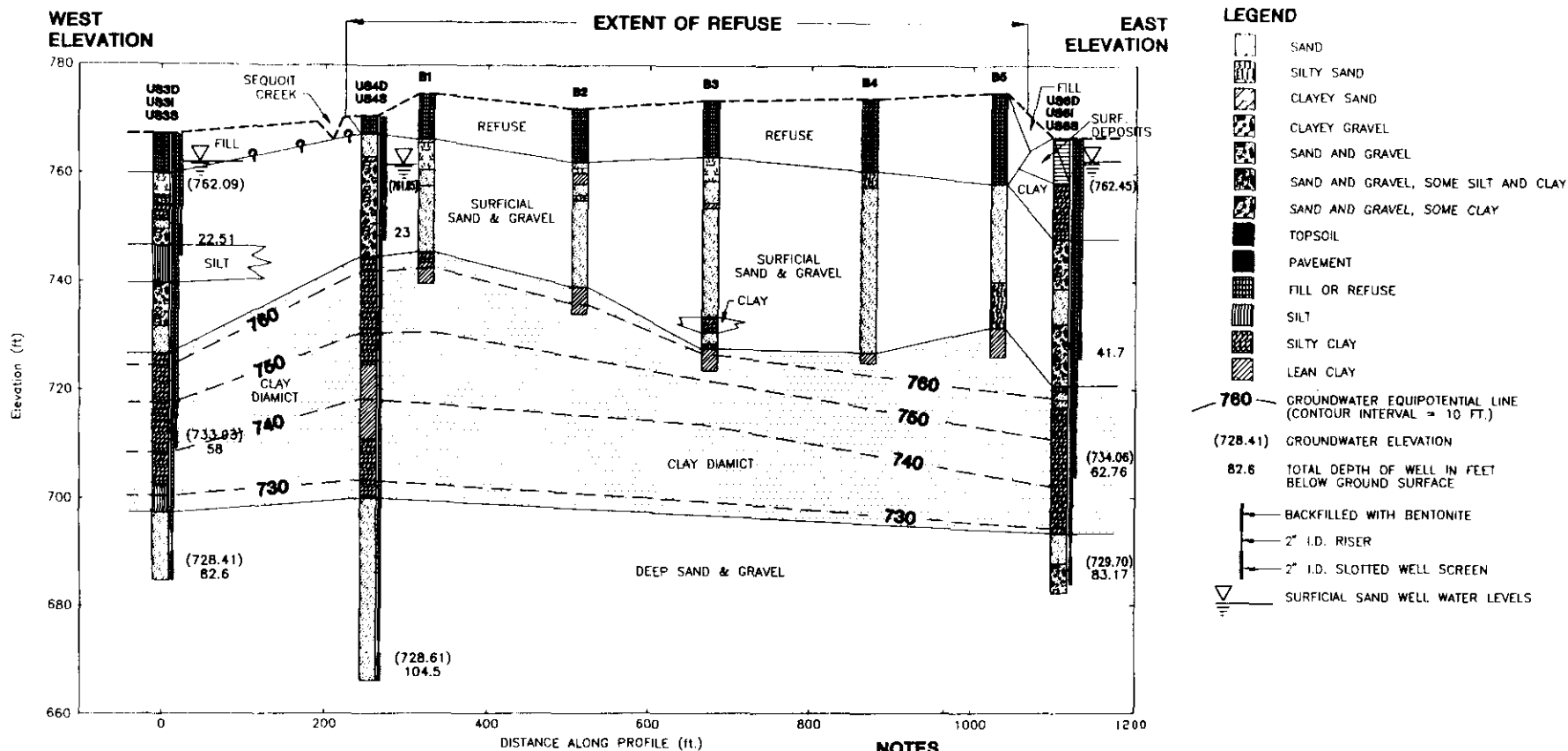
GEOLOGIC CROSS-SECTION B-B'

REMEDIAL INVESTIGATION
 H.O.D. LANDFILL
 WASTE MANAGEMENT OF ILLINOIS, INC.

Drawing Number
 10010201 E



Developed By: SUC
 Approved By: SUC
 Drawn By: CCM
 Date: 10/16/93
 Reference: None



SECTION C - C

CROSS SECTION SCALE



SCALE IN FEET
 VERTICAL EXAGGERATION: 6.65 TIMES

NOTES

1. THE STRATUM LINES ARE BASED ON INTERPOLATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.
2. FOR THE PURPOSE OF ILLUSTRATING SUBSOIL CONDITIONS ON THE CROSS-SECTIONS, SOME OF THE BORING LOGS HAVE BEEN SIMPLIFIED. FOR A DETAILED DESCRIPTION OF SUBSURFACE CONDITIONS AT INDIVIDUAL BORINGS REFER TO SOIL BORING LOGS. (APPENDED TO REPORT)
3. COMPLETE MONITORING WELL INSTALLATION DETAILS ARE APPENDED TO REPORT.
4. CROSS-SECTION HAS BEEN EXAGGERATED 6.65 TIMES.
5. HORIZONTAL DISTANCES ARE MEASURED WITH RESPECT TO THE CENTER OF EACH SOIL BORING LOCATION.
6. ELEVATIONS ARE SHOWN IN REFERENCE TO U.S.G.S. DATUM.
7. QUESTION MARKS INDICATE THE CORRELATION OR EQUIPOTENTIAL LINES ARE INFERRED.
8. GROUNDWATER ELEVATIONS ARE BASED ON MEASUREMENTS OBTAINED BY WARZYN INC. ON JUNE 8 AND 9, 1993. CONTOURS ARE EXTRAPOLATED BASED ON CALCULATED VERTICAL HYDROLOGIC GRADIENTS. SEE TABLE 5 OF TECHNICAL MEMORANDUM NO. 1 TEXT.

FIGURE 15

LEGEND

- SAND
- SILTY SAND
- CLAYEY SAND
- CLAYEY GRAVEL
- SAND AND GRAVEL
- SAND AND GRAVEL, SOME SILT AND CLAY
- SAND AND GRAVEL, SOME CLAY
- TOPSOIL
- PAVEMENT
- FILL OR REFUSE
- SILT
- SILTY CLAY
- LEAN CLAY
- 760 GROUNDWATER EQUIPOTENTIAL LINE (CONTOUR INTERVAL = 10 FT.)
- (728.41) GROUNDWATER ELEVATION
- 82.6 TOTAL DEPTH OF WELL IN FEET BELOW GROUND SURFACE
- BACKFILLED WITH BENTONITE
- 2" I.D. RISER
- 2" I.D. SLOTTED WELL SCREEN
- SURFICIAL SAND WELL WATER LEVELS

Developed By: SJC
 Drawn By: CCM
 Approved By: [Signature]
 Reference: [Signature]
 Revision: [Signature]

REMEDIAL INVESTIGATION
 H.O.D. LANDFILL
 WASTE MANAGEMENT OF ILLINOIS, INC.

Drawing Number
 10010201

